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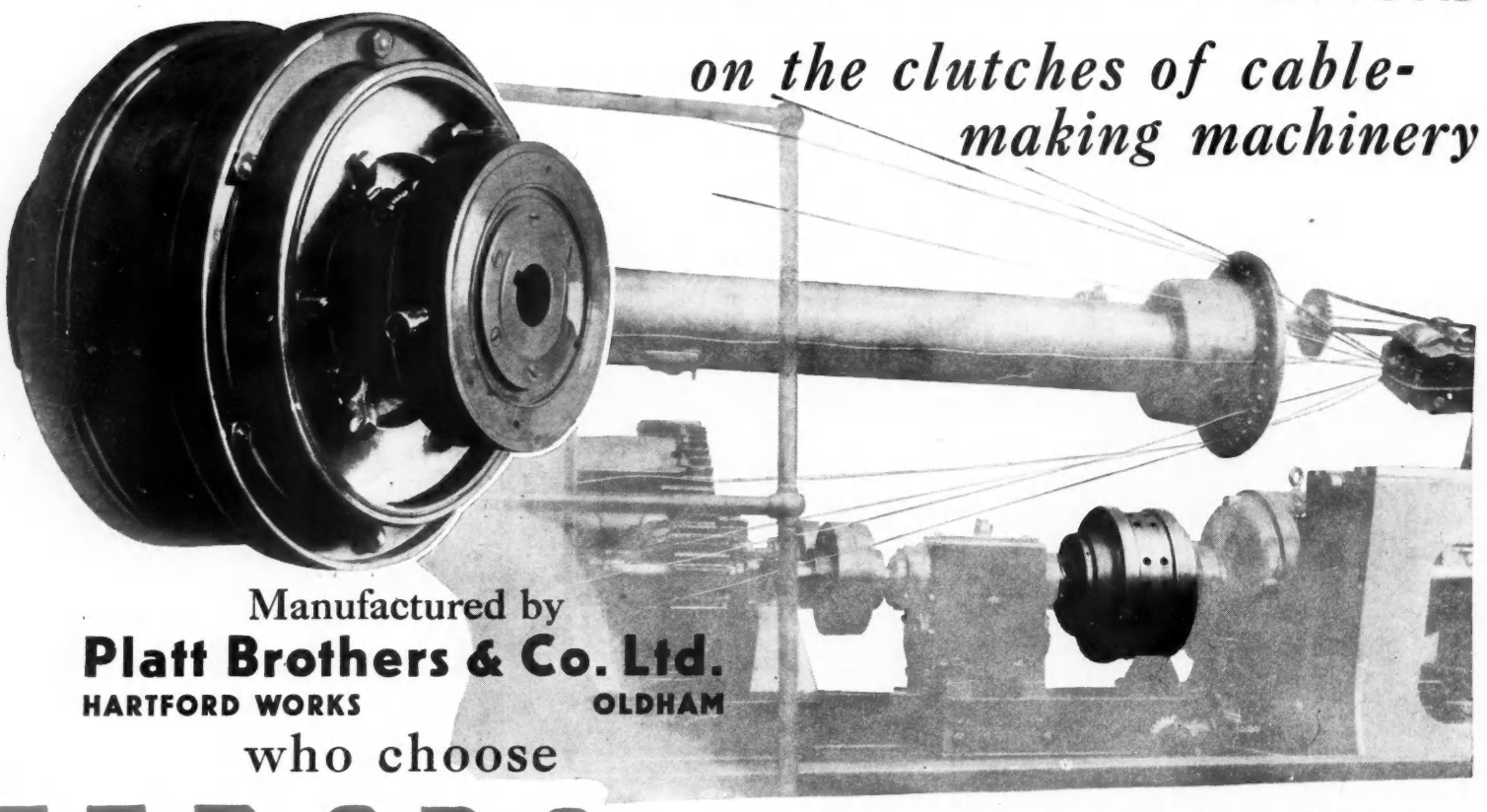

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A Seven-Day Journal

The London Iron and Steel Exchange.

IT has just been announced that Mr. C. Bruce Gardner, M.I. Mech. E., has accepted the chairmanship of the London Iron and Steel Exchange, in succession to the Right Hon. Lord Greenwood, P.C., whose term of office will expire at the end of the year. Mr. Bruce Gardner is managing director of Securities Management Trust, Ltd., a director of the Bankers' Industrial Development Company, Ltd., and of Credit for Industry, Ltd., and chairman of Sir W. G. Armstrong, Whitworth and Co. (Engineers), Ltd. He was born in London in 1887, and is the son of Mr. Henry Gardner, the founder and chairman of Henry Gardner and Co., Ltd., one of the leading merchant firms operating on the London Metal Exchange. He was educated at St. Dunstan's College, and after receiving technical training at the Battersea Polytechnic, was apprenticed to the British Westinghouse Company, Ltd., Trafford Park, Manchester, now Metropolitan-Vickers Electrical Company, Ltd. On completing his apprenticeship he joined John Summers and Sons, Ltd., as junior engineer, and at the early age of twenty-seven he became one of the managing directors of the firm. Later he became a director of the Wolverhampton Corrugated Iron Company, Ltd., the Staffordshire Chemical Company, Ltd., the Steetley Lime and Basic Company, Ltd., and a number of other commercial undertakings, and in 1922 joined the board of the Shelton Iron, Steel and Coal Company, Ltd., as managing director, retaining at the same time his connection with John Summers and the other companies. He was also chairman of the Flintshire Coalowners' Association, of the Galvanising Conciliation Board, and of the Iron and Steel Industrial Research Council of the British Iron and Steel Federation, as well as a member of the Advisory Committee of the Department of Overseas Trade. In 1930 he resigned his other interests on accepting an invitation to become managing director of Securities Management Trust, Ltd., and a director of the Bankers' Industrial Development Company, Ltd., organisations formed under the auspices of the Bank of England to assist in financing schemes of rationalising the basic industries. Later he became a director of Credit for Industry, Ltd., formed as a result of the Macmillan Report to afford assistance to the smaller industries.

Miners' Wages.

A MEMORANDUM on miners' wages was issued a few days ago by the colliery owners of Great Britain. It challenges the statement that the average earnings of the miners is barely £2 a week, and shows that even before necessary corrections were made the average in 1934 was approximately £2 5s. a week. This "average" includes youths under twenty years of age, of whom there were 110,000 at work on December 15th, 1934, and 125,700 surface workers. It is admitted that the number of shifts worked is low—as a consequence of the Government's desire to see employment spread over as many men as possible—but it estimates that if 5½ shifts be taken "as what a man might be reasonably expected to work in times of normal trade," then the average for workers at the coal face, boys and youths included, would be 62s. per week, exclusive of allowances on rents and domestic coals. The memorandum estimates that if an increase in wages of 2s. per shift for adults and 1s. per shift for workers under eighteen years of age were granted, the cost would approximate to 18½ million pounds sterling per year, and 1s. 10d. per ton on commercially disposable coal, or if the inland market alone is considered 2s. 6d. per ton. No such sum as 18½ million pounds is available in the industry, for where collieries are not run at an actual loss the profits are small. The memorandum discusses the miners' allegation that there are hidden profits by the sale of coal to associated industries, and points out that coal transferred to "all associated undertakings must be transferred at fair market prices." There are safeguards to ensure that this regulation is observed, and the accountants of the miners have expressed their approval of them.

Withdrawal of the Majestic.

IT was announced on Tuesday, December 10th, that the Cunard White Star liner "Majestic" (56,621 tons) was to be withdrawn from service in February and to be sold to shipbreakers. The "Majestic" was the biggest liner in the world until the "Normandie" was built. She was laid down in Hamburg just before the war and named the "Bismarck" by the Kaiser. The war prevented her completion in Germany and she was handed over, together with the "Imperator" and the "Vaterland" under the Reparations scheme to the White Star Line. She completed her four hundredth Atlantic crossing three months ago, and has covered a distance of about 1½ million miles. This decision implies that the old White Star Line will be represented in service only by two ships, the "Georgic" and the "Britannic." At the time of the Cunard White Star merger, seven White Star ships were taken over by the new company. They were the "Majestic," "Olympic," "Doric," "Georgic," "Homeric," "Laurentic," and "Britannic." The remainder of these ships have either been sold or are for sale. The express service between Southampton and New York will now be operated by three Cunard liners, the new "Queen Mary," the "Aquitania" (45,645 tons), and the "Berengaria" (52,101 tons). The "Majestic's" last trip will be her return from New York on February 14th, reaching Southampton on February 21st.

Rebuilding Wandsworth Bridge.

PROPOSALS for the rebuilding of Wandsworth Bridge are detailed in the agenda of the London County Council for consideration at a future date. Although the Council has in hand the construction of two Thames bridges, the Highways Committee is stated to believe that the reconstruction of Wandsworth Bridge should be delayed no longer. It considers that, subject to a grant from the Road Fund of not less than 60 per cent. of the net cost being agreed to by the Ministry of Transport, the Council should agree to proceed with the scheme. The estimated cost of the scheme submitted is given as £470,000, to be borne as to £1000 in the present financial year, as to £169,000 in 1936–37, as to £120,000 in 1937–38, as to £120,000 in 1938–39, and as to £60,000 in 1939–40. The estimated duration of the work is three years. The existing bridge was opened in 1873. It has a width of 30ft. The proposed new bridge is to be 60ft. wide, the carriageway being 40ft. wide. The possibility of widening it at a later date to 80ft. overall has been allowed for in the plans. The design is for a steel bridge of the three-span cantilever type with granite faced piers and abutments. The centre span has a clear width of 283ft. between the pier faces and a headway at the centre of about 21ft. above Trinity high-water level. The present bridge has a span of 126ft. at the centre and 19ft. 9in. headway. During the period of reconstruction of the bridge a temporary footbridge would be provided on the downstream side.

Work and Unemployment in November.

ON November 25th according to the returns of the Ministry of Labour issued on Monday of this week the number of insured persons at work was 10,537,000. This figure, the highest ever recorded, represents an increase of 45,000 during the month. It is 315,000 more than the number employed a year ago, 581,000 more than the figure returned two years ago, and 1,164,000 more than the number at work three years ago. The increase in the employment figure over that returned on October 21st was, it is stated, largely ascribable to the reduction in the number of people engaged in industrial disputes. On November 25th the total number of unemployed amounted to 1,918,562. While this figure is 2172 more than that returned a month ago it is 202,223 less than that given a year ago and 881,244 less than that for three years ago. The principal decrease in unemployment during November was 29,016 in the coal-mining industry. Although this reduction was presumably caused by the return to work of miners who had been on strike it should be noted that during the past year the number of unemployed miners has fallen by 60,829. Other industries which showed a decreased amount of unemployment during November were the cotton, shipbuilding, engineering and iron and steel trades. Industries returning increased unemployment figures included the building trades, tailoring, hotel services, shipping, the manufacture of motor vehicles and electrical manufatture. All the increases in unemployment, it is stated, were attributable to seasonal causes.

The Naval Conference.

ON Monday of this week, December 9th, the five-power Naval Conference was begun in London, representatives being present from Great Britain, France, Italy, the United States, and Japan. In an opening speech Mr. Baldwin declared that this country was ready to prolong the principles of the Washington and London naval treaties with certain modifications and adjustments. We desired, he said, a reduction in the sizes of all the larger types of ships and of the guns which they carried and still pressed for the abolition of the submarine. Failing the abolition of submarines, he continued, it was of vital importance to reach an agreement that would prevent their misuse. He announced that France and Italy were prepared to accept the rules regarding the treatment of merchant ships by submarines in time of war which were laid down in the London Naval Treaty and which were already in force between the United States, Japan, and the British Commonwealth of Nations. The principal delegate of the United States, Mr. Norman Davis, read a letter from President Roosevelt in which the United States policy was stated to be emphatically in favour of a substantial reduction—20 per cent. if possible—in the existing treaty tonnages. The French Ambassador, speaking for his country, said that France continued to be favourable to the adoption of drastic limitations but new factors had recently arisen which would prevent his country from binding herself to limit her naval armaments except for a short period. Signor Grandi stated that Italy's aim continued to be the avoidance of an armaments race but said that it would not be easy to lay down a rigid solution of the problem to cover a long period of time. Admiral Nagano, speaking for Japan, also adhered to the principle of a substantial measure of disarmament but in a subsequent interview he stated that Japan would uphold her demand for a common upper limit of tonnage for all first-class navies and would in no circumstances agree to the abolition of submarines. The Japanese delegation it appears is equally firm in opposing the all-round cut of 20 per cent. in tonnage suggested by America.

London Passenger Transport.

CONCLUDING a paper on the Development of Town and Country Road Passenger Services at the Institute of Transport on Monday, December 9th, Lieut.-Colonel A. W. C. Richardson asked if he might speculate as to the future and the possible developments as they apply to transport in the London area. He wondered if the charge of lack of imagination in our predecessors might not be levelled against those who at the present time are responsible for transport. He regarded such expedients as one-way working, fixing of bus stopping places, widening of roads, and the provision of roundabout workings and traffic lights as to some extent merely palliatives, which are hardly keeping pace with the growth of traffic to-day. "To avoid the criticism of those who follow after us in the world of transport," he said, "we ought at once to make bold plans for immediate reconstruction of our roads, pedestrian pathways, parking places, junctions, bottle necks, and narrow streets. Traffic must not be slowed down; it must be speeded up, not in parts, causing congestion elsewhere, but as a whole. To do this, pedestrians must be removed from the motor roads and accommodated, safely and comfortably, above the traffic, on a level with the first floor of buildings and shops, such pathways to be connected across the roads by means of bridges. Shop windows will be on the first floor instead of the ground floor, and buildings and shops must be set back or arcaded, where this is feasible. The ground level will thus be freed for its legitimate use, the accommodation of traffic, both moving and stationary."

The Transatlantic Air Mail Service.

ON Thursday, December 5th, at a conference attended by representatives of the five nations—Great Britain, the United States, the Irish Free State, Canada, and Newfoundland—at Washington, tentative approval was given to the projected scheme for a Transatlantic air mail service. The Postmaster-General of the United States of America, Mr. Farley, declared that he intended to ask for the funds necessary. Two alternative routes are to be used, the most favoured being the shorter northern route—London, Ireland, Newfoundland, Montreal, New York, Washington—at all of which places landing stations will be provided. The southern route, favoured originally by the American spokesmen on account of its more favourable weather conditions, is London, Paris, Lisbon, Azores, Bermuda, New York. The first experimental flights will be made between March 15th and May 15th next year, and mail cargoes are to be carried by the surveying planes. It is estimated that the value of the mail contracts will defray the entire cost of the service during the first year of operation. Pan-American Airways and Imperial Airways will be joint operators, sharing the preliminary expenses and each receiving the mail contract for one direction, westbound flights being handled by Imperial Airways. It has been decided that two radio beacons are to be anchored in the Atlantic to serve as guides to the planes.

The Tatsfield Air Disaster.

SHORTLY before five o'clock in the evening of Tuesday of this week, December 10th, a Belgian air liner flying from Brussels to Croydon crashed on a wooded hill near Tatsfield, Caterham, Surrey. All the passengers, numbering seven, and all the crew, numbering four, were killed. The weather at the time of the disaster was cold and it is stated that the machine was flying low as the result of the formation of ice on the wings. If this explanation of the disaster is substantiated, the accident will have to be added to a lengthening list of mishaps arising from the same cause. It should be noted that the actual weight of the ice which forms on the wings and other parts is quite small and is not in itself sufficient to overload the machine. The real explanation lies in the fact that the ice builds up on the leading edge of the wings giving that edge a new and highly inefficient aerodynamic profile. As a result, the lift of the wing is seriously reduced and its drag greatly increased. Ice also builds up on the front edge of the struts, stay wires, and other parts and, although its total weight is quite small, materially increases the resistance of those parts. A system of avoiding the formation of ice on aircraft, originally devised at the R.A.E., Farnborough, was described in our issue of July 5th this year. Among the victims of the Tatsfield disaster we regret to have to include the name of Sir John Carden, a technical director of Vickers-Armstrongs, Ltd., and well known for his work on the Carden-Lloyd tractor and light tank.

Mechanical Flow Meters.

By Dr. F. V. A. E. ENGEL and R. J. WEY.

No. III.

(*Concluded from page 586, December 6th.*)

MECHANICAL INTEGRATORS.

PRACTICALLY all flow-measuring devices used in industry must be of the integrating type, *i.e.*, they must record upon a counting device the total quantity of fluid passing in any given period of time. It thus becomes necessary with differential operated flow meters to provide a means of continuously integrating the product of rate of flow and time. There have been developed many methods of performing this operation, all of which belong to either one of two broad classes. The first of these may be termed the "continuous integration method," whilst the second may be termed the "intermittent integration" method.

CONTINUOUS INTEGRATORS.

These are of the frictional drive type in which the velocity ratio of a variable-speed gear interposed between a counter and a constant-speed drive, such as a clock, is varied according to the rate of flow, as measured by the flow meter. The counter is thus driven continuously at a speed proportional to the rate of flow of the fluid at any instant, so that the dials of the counter may be calibrated directly in units of quantity, *e.g.*, lb. of steam.

The principle of the frictional drive variable-speed gear dates back to 1824, when Gonella[20] devised area integrators, *i.e.*, planimeters, employing a wheel in frictional contact with a disc or cone. Before 1838 Poncelet[21] suggested the use of a disc and roller for integrating work in dynamometrical measurements, and since then this principle, or modifications of it,

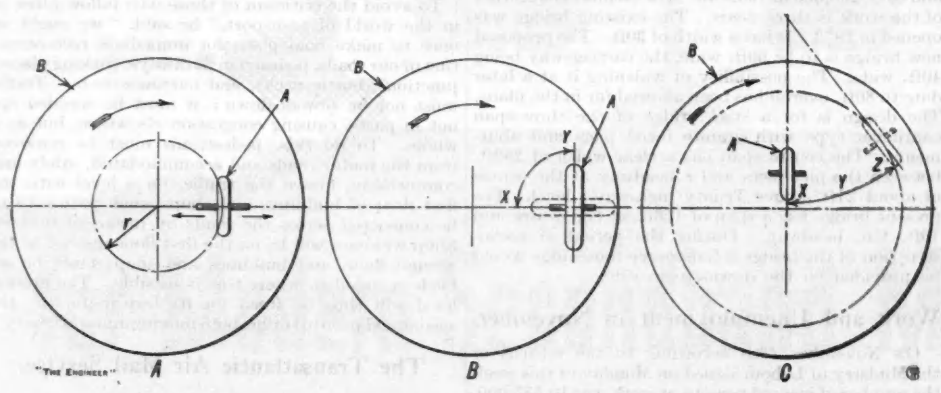


FIG. 16 *(A, B and C)*—FORMS OF WHEEL AND FRICTION DISC TYPE INTEGRATORS

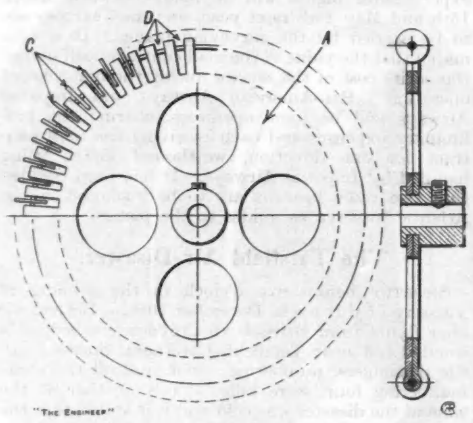


FIG. 17—SHOWING ANTI-FRICTION ROLLERS

has been frequently applied for the integration of work and other allied purposes.[22]

In its original form the method of friction disc and roller suffers from several disadvantages,[23] due to the contradictory conditions of motion of the wheel upon the disc. Referring to the diagram, Fig. 16A, it will be seen that as the axis of the wheel A is radially disposed with regard to the friction disc B, when this rotates it will, in theory, turn the periphery of wheel A at the same circumferential speed as that of the disc at radius *r*, assuming that the pressure of the wheel upon the disc is sufficient to prevent slipping. In practice, however, errors are present, due to the finite width of the surfaces in contact, and a grinding action will take place resulting in further widening of the surface of wheel A, and so increasing the errors. Also, when the axial position of wheel A is varied to alter the velocity ratio between B and A, it is evident that it must slip in moving over the surface of B. This has been shown by Dr. Hele-Shaw (*l.c.*) to produce errors in the angular rotation of wheel A, and hence in the integrated quantity recorded by the counter driven by wheel A.

In order to eliminate these errors, Professor James Thomson in 1876 invented the disc, sphere, and cylinder integrator,[24] a classic example of the application of this being in the tide-predicting machine of Sir Wm. Thomson (Lord Kelvin). This principle, however, does not appear to have been applied to integrators for flow measuring purposes.

In connection with flow measurement, the continuous integrator using wheel and friction disc was first applied by Lord Kelvin to G. F. Deacon's cone-and-disc flow meter. In this meter the movement of the float rod was made to vary the position of a friction wheel, which was drawn across the centre line of a horizontal clock-driven disc. A fusee device was interposed between the meter float rod and the friction wheel, in order to obtain a linear relationship between the rate of flow and the distance of the friction wheel from the centre of the disc.[25]

At the present time the wheel and friction disc method is used by several manufacturers of flow meters, and may be divided into three types, which will now be described.

The first type is identical in principle with the wheel and friction disc device applied by Lord Kelvin to Deacon's meter, as described above. In the practical application, however, the fusee is usually replaced by a cam and follower for imparting the correct motion to the wheel and the wheel is specially constructed to reduce the grinding action which tends to occur. As shown in Fig. 17, a series of small freely pivoted wheels C are mounted in slots D around the periphery of the main wheel A, which can then be freely moved radially across the surface of the friction disc, the small wheels rotating when this occurs.

In the second type, which is a modification of the main principle, the distance of the friction wheel from the centre of the disc is kept constant, but the inclination of its axis is varied (see Fig. 16B). It will be evident that as the axis of the wheel A is turned from X to Y, the rate of rotation of the wheel falls from a maximum to zero. Owing to the variation in position of the axis of the wheel, however, it is necessary to couple this to the counter by means of a pair of bevel wheels driving a shaft having the same axis as that about which the wheel is turned to vary its rate of rotation. Due to this an instantaneous error is introduced, this error being proportional to the angle of rotation of the friction disc from the zero position.

This gives rise to the peculiar effect of apparently negative rates of integration occurring when the rate of rotation of the counter in a backward direction due to variation of angular position of the wheel is greater than the rate of rotation in a positive direction due to the action of the friction disc and wheel. Another disadvantage is that the point of contact of the friction disc and the wheel always occurs at a fixed radius which would tend to cause excessive local wear of the friction wheel B.

The third type is virtually a combination of the two other types, in that a combined radial displacement and angular rotation of the wheel takes place. Referring to Fig. 16C, it will be seen that when the wheel A is in position X, no rotation will take place due to the rotation of the friction disc, but instead the small rollers around its periphery will rotate with maximum velocity. As the wheel is moved through the arc X Y Z, the rate of motion of the portion of the disc in contact with the wheel increases, due to the point of contact moving outwards, and simultaneously the axis of the wheel approaches a radial position with respect to the friction disc until when the wheel is in the position Z its peripheral velocity is equal to the velocity of the friction wheel at the point of contact, no rotation of the small anti-friction wheels then taking place.

MULTIPLICATION GEAR.

The principle of the intermittent integrator dates from 1820, when Chevalier Chas. X. Thomas, of Colmar, designed and produced the first calculating machine in which multiplication was performed directly. In this machine, which was called the Thomas de Colmar "arithmometer," the primary element is a cylinder having teeth of varying axial length on its outer surface. Slidably mounted on a spindle parallel to the axis of the cylinder is a pinion which meshes with the teeth on the cylinder, so that when the cylinder is rotated this pinion is driven intermittently by an amount proportional to the number of teeth on the cylinder which engage with the pinion, which, in turn, depends upon the axial position of the pinion in relation to the cylinder.[26]

In the practical application of the principle to mechanical integrators used in connection with flow measurement, the toothed cylinder A (Fig. 18) is rotated at constant speed by the clock B, whilst the axial position of the pinion C is determined by the position of the meter float which is coupled to the rod F. The pinion C is free to slide upon the shaft D, which is square or of other suitable section, so that the rotation of the pinion is imparted to it. The

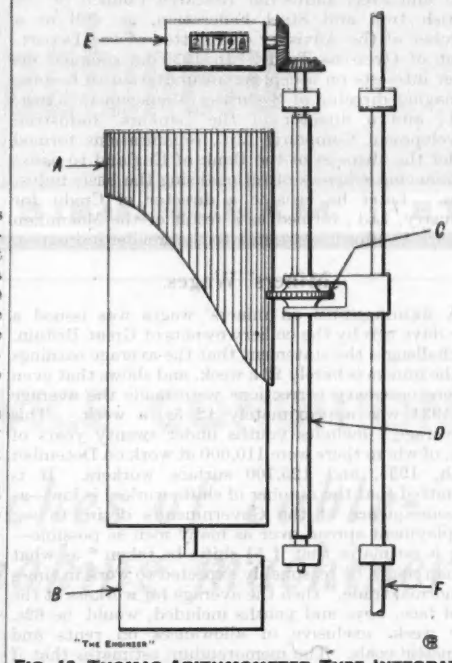


FIG. 18—THOMAS ARITHMOMETER TYPE INTEGRATOR

lengths of the teeth on the cylinder A are so proportioned that the number which will mesh with the pinion as the cylinder turns through one revolution is proportional to the flow corresponding to that position of the pinion. It will be seen that it is possible to take into account the variations of coefficients of the flow equation by suitably proportioning the lengths of the teeth. The counter E coupled to the rod D is then turned intermittently by an amount proportional to the rate of flow at that time. A modification of the general principle is used in the integrator illustrated diagrammatically in Fig. 19.[27] The toothed cylinder is replaced by a cylindrical cam A, which is rotated at a constant speed by the clock B. A roller C is mounted on a bracket D capable of being moved vertically along the square shaft E by the movement of the float coupled to the rod F. The rod E is connected at its lower end to a clutch G through which the counter H may be coupled to the clock B, being arranged so that when the cam A during its rotation deflects the roller C, the clutch disconnects the counter from the clock. The counter is thus driven for an amount proportional to the time of engagement of the clutch. The cam, of course, is shaped so that this time is proportional to the flow corresponding to any position of the roller C.

CAM AND FEELER TYPE.

This type of integrator is characterised by the provision of a mechanically oscillated feeler device,

[20] Napier Tercentenary Celebration Handbook, page 190, edited by E. M. Horsburgh, published by the Royal Soc. of Edinburgh, 1914.

[21] Hele-Shaw, "Mechanical Integrators," "Proc.," Inst. Civil Engineers, Vol. 82, 1885, pages 125–143.

[22] Eleventh Report of British Association, page 308.

[23] Hele-Shaw, "Theory of Continuous Calculating Machines," "Phil. Trans.," Royal Soc., 1885, Vol. 176 (2), page 367.

[24] See "Napier Tercentenary Celebration Handbook," page 192, and Professor James Thomson, "An Integrating Machine having a New Kinematic Principle," "Proc.," Royal Soc., London, Vol. 24, 1876, pages 262–265.

[25] "A Dictionary of Applied Physics," edited by Sir Richard Glazebrook, Vol. III, London, 1923, page 567.

[26] Science Museum Catalogue, Mathematics, Section 1, "Calculating Machines and Instruments," compiled by D. Baxandall, page 20. (H.M. Stationery Office, 1926).

[27] "Hydraulics," by F. C. Lea. London, 1930, page 366.

in the path of which is situated an integrator cam operated by the float or other mechanism controlled by the differential pressure. The feeler is oscillated, generally by a clockwork motor or a synchronous electric motor, so that the tip periodically comes into contact with the edge of the integrator cam, which thus prevents further motion of the feeler, the drive from the clockwork motor or synchronous motor being so designed that this is unaffected by the position at which the feeler is arrested by the cam. Coupled to the feeler by a ratchet or other similar mechanism is the integrator counting device, which is thus turned periodically by an amount proportional to the angular motion of the feeler, which, in turn, is controlled by the position of the cam. It is immaterial whether the ratchet mechanism is arranged

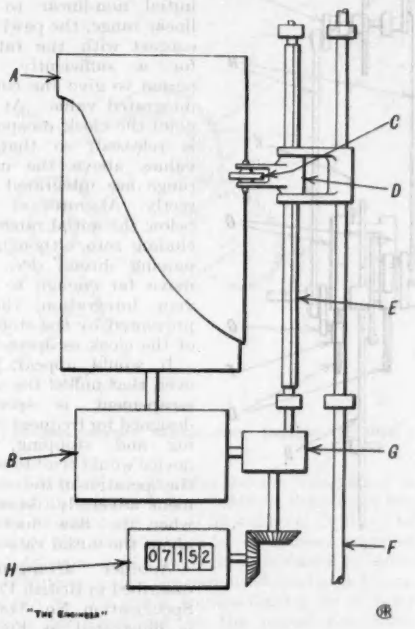


FIG. 19—MODIFIED THOMAS INTEGRATOR. OPERATED BY CLUTCH

to drive the counter during either the motion of the feeler towards or away from the cam, since the angular deflection is the same in both cases. In order to prevent integration at zero and low loads, it is simply necessary so to shape the cam that the motion of the feeler is totally prevented over the desired range.

It is evident that for the successful operation of this arrangement, it is necessary that no appreciable reaction be transmitted to the measuring device from the integrator cam when the feeler operates, as this would tend to deflect the measuring device from its correct position.

The two most important practical forms of this integrator will now be described. In the first type the integrator cam is clamped during the period of operation of the feeler device. This necessitates a flexible coupling between the measuring device and the cam, so that changes of flow taking place when the integrator cam is clamped can be followed by the measuring device.

A good example of this type of integrator is described in British Patent Specification No. 18,709/1914. It is shown diagrammatically in Fig. 20, in which A represents the integrator cam driven by means of a flexible coupling (not shown) from the meter float or other measuring device. Mounted on the same spindle is a brake drum B with which a brake shoe C co-acts. The brake shoe is intermittently depressed by means of the cam or crank device D, which is mounted on a shaft driven at constant speed. Mounted on the same shaft is a cam E, which periodically depresses and releases the lever F, thus periodically raising and releasing the feeler G, which, when released, makes contact with the cam A. Also mounted on the constant-speed spindle is a third cam H, which, except during that period when the feeler is being raised from the cam A, deflects the lever I to which are coupled two arms J. These arms, when thus deflected, make contact with the edges of the friction disc K and force this axially against the action of a spring, so that it is no longer in contact with the two rods L attached to the lever F.

The sequence of operations taking place is as follows :—The brake shoe C is depressed for a short interval, allowing the cam A to take up a position corresponding to that of the measuring device. The brake shoe then locks the cam into position and, the friction disc K being out of contact with the rods L and at the same time prevented from rotating as a result of vibration or rocking, such as would occur on board ship, for example, by the arms J, the feeler G is allowed to descend, its motion being arrested at some point by the cam A. The cam H then releases the friction disc K, allowing it to make contact with the rods L, after which the cam E raises the feeler G to its maximum position, turning the disc K in a clockwise direction during this process. The angle through which this disc is turned is determined by the position of the cam A, which is shaped so that the angular deflection of the feeler is proportional to the rate of flow corresponding to any given position of the cam A. The disc K, which is coupled to the counter, is thus driven intermittently by an amount proportional to the flow.

Further rotation of the constant-speed spindle causes the cam H to deflect the lever I and the arms J, thus withdrawing the friction disc K from contact with the rods L; the sequence of operations then begins again.

In the second type the period of contact between the feeler tips and the integrator cam is made very small, in some cases a fraction of a second, so that very little reaction on the cam is caused. It is evident that in this case a flexible coupling between the meter float and the integrator cam is unnecessary, since the time of contact of the feeler and the cam is so small that the flow cannot vary by any appreciable amount during this period. Two methods of achieving this have been developed and will now be described.

(1) This method makes use of an intermittent drive to the cam device which lifts the feeler from the actual integrating cam. The clock drive is so arranged that the spindle on which this feeler operating cam is mounted is rapidly rotated for exactly one revolution and then stopped for a period, of say 30 seconds. During the short period when the cam is being rotated the feeler is allowed to touch the integrator cam, but during the much longer period which follows the feeler is lifted clear of the integrator cam.

An interesting device of this nature is described in British Patent Specification No. 207,407.[28] Referring to Fig. 21, it will be seen that the feeler arm A, pivoted at B, is raised clear of the integrator cam C by the cardiod cam D, which is coupled by gearing to a spring motor or other source of power at E tending to rotate the cam in an anti-clockwise direction. Also coupled by step-up gearing to the cam spindle is a spindle F carrying a catch G and an air vane brake M, likewise tending to rotate in an anti-clockwise direction, but normally prevented from doing so by a notch in the lever H engaging with the catch G. Thus the cardiod cam D is prevented from rotating, and when in this condition holds the feeler clear of the integrator cam C.

An excentric pin I, rotated at a constant speed by means of a clock drive, lifts the lever H once per revolution. When this occurs the catch G is released and the spindle F, and hence the cam D, start rotating, the speed being limited by the air vane brake M attached to spindle F. When the cam D has turned through a small angle a cam J mounted on the same spindle raises the cranked end of lever H, holding the opposite end clear of the rotating catch G and the excentric pin I, so that no load is imposed upon the clock mechanism used for rotating this pin. After the cam D has made one revolution the cranked end of lever H slips into the notch in cam J, allowing the rotation of the catch G to be arrested by the notch in lever H, the pin I by this time having travelled clear of the end of the lever H. It will thus be seen that the cardiod cam D is rotated for exactly one revolution every time the pin I trips the lever H, the feeler A being therefore rapidly lowered on to the cam C and then raised to its original position. During this latter operation the motion of the feeler is transmitted to the counter L by means of a ball and ratchet friction clutch K. The advantage claimed for this mechanism is that the timing clock has no heavy work to do, the necessary power to operate the integrating mechanism being supplied by a powerful spring motor or other source of power.

An ingenious modification of this principle is employed in another form of this integrator, in which the necessity for a separate source of power for operating the timing clock is dispensed with by causing the intermittently driven cam spindle to wind up a light spring at the same mean speed as it runs down in driving the clock escapement. The mean torque applied to the clock escapement is then constant and independent of the variations in torque of the main driving spring, so long as this is above that which is required to wind the light spring.

(2) In this method a trip device is employed which allows the feeler to drop rapidly away from contact with the integrator cam a fraction of a second after

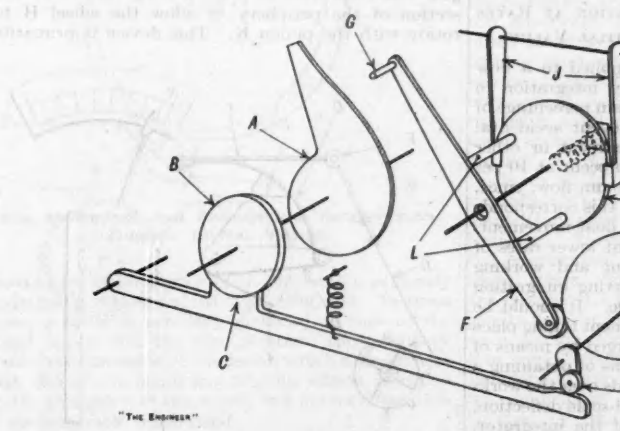


FIG. 20—EARLY FORM OF CAM AND FEELER INTEGRATOR

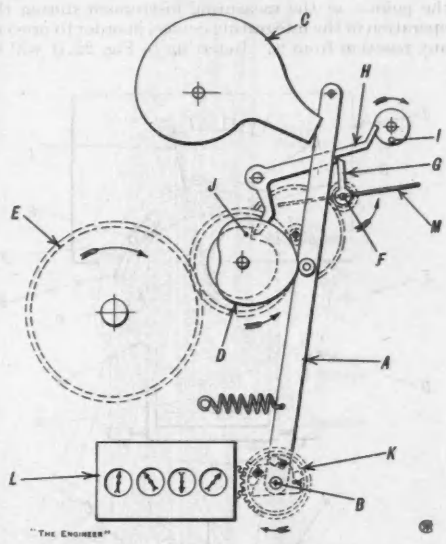


FIG. 21—QUICK ACTION CAM AND FEELER INTEGRATOR

touching it. This action is obtained by driving the feeler arm from a constant-speed motor through a lightly constructed dog clutch, the engagement or otherwise of which is determined by the pressure upon the tip of the feeler. Thus, whilst the feeler tip is free, *i.e.*, not touching the surface of the integrator cam, the clutch is engaged, and the feeler tip is driven at constant speed towards the cam. At the same time, a pawl attached to the feeler engages with a ratchet wheel coupled with the counting train, which is thus driven at constant velocity during this period.

At some point in its travel, depending upon the position of the integrator cam, the feeler tip touches the surface of the integrator cam, and a very slight further movement of the feeler causes sufficient pressure to be exerted upon the feeler tip to disengage the clutch. When this occurs the feeler is free to fall away from the cam by gravity or under control of a spring, coming to rest against a fixed stop. The pawl driving the counting train, of course, slips during this return stroke of the feeler.

The feeler tip now being out of contact with the integrator cam, the clutch is free to engage when the position of the constant-speed rotating member is such that this can occur. This obviously can occur only at definite intervals determined by the rate of rotation of the member and its number of teeth. Thus the feeler is driven towards the cam at definite intervals of time touching this only for a fraction of a second before returning to zero.

PAWL AND RATCHET DEVICES.

This type, like the cam and feeler type, is intermittent in action, the counter being rotated successively by increments proportional to the rate of flow at that time. The principle is very simple and various modifications in design are possible in practice. One or more pawls attached to arms and coacting with a ratchet wheel connected with the counting train are driven continuously around the common axis by means of a clock or constant-speed motor. These pawls are capable of being lifted out of contact with the teeth of the ratchet by external means, such as a shroud interposed between the pawl and the teeth of the ratchet wheel, or by means of a cam operating

[28] See also H. Diederichs and W. C. Andrae, "Experimental Mechanical Engineering," Vol. I, "Engineering Instruments," page 698, New York, 1930.

on a lever attached to the pawls. This shroud or cam is coupled to the measuring device in such a manner that its angular deflection about its axis is proportional to the flow, the maximum deflection of this shroud being any angle up to 180 deg.

Also capable of lifting the pawls out of contact with the ratchet teeth is a fixed shroud or cam, arranged so that the pawls normally engage with the teeth as they turn through an angle of 180 deg., but during the second 180 deg. are disengaged. It will be seen that if the movable shroud or cam is in such a position that the pawls are disengaged by it during the first 180 deg., no rotation of the ratchet wheel results, but that as the movable shroud or cam is rotated, the pawls engage with the ratchet wheel for a longer time at each revolution of the arms carrying the pawls, until when the shroud has moved through 180 deg. the pawls also engage for 180 deg. If two pawls, diametrically opposed, are used, the rotation of the ratchet wheel is continuous under these conditions (*i.e.*, maximum deflection of the shroud) as when one pawl is disengaged by the shroud or cam, the opposite pawl is simultaneously engaged.

An early form of this device for use with galvanometers or electrical measuring instruments, and in a modified form for integration of dynamometer torques, is described in British Patent Specification No. 1097, 1884, of Marcel Deprez, well known in connection with the development of the Deprez-D'Arsonval galvanometer. The mechanism is the forerunner of the modern types of ratchet and pawl integrators, but in its original form does not use fixed and moving shrouds. The instrument is very interesting in that it incorporates means for clamping the pointer of the measuring instrument during the operation of the integrating device, in order to prevent any reaction from it. Referring to Fig. 22, it will be

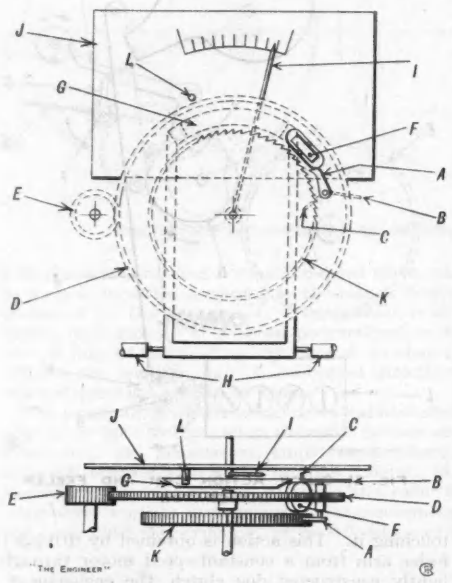


FIG. 22—MARCEL DEPREZ RATCHET AND PAWL INTEGRATOR, 1884

seen that the pawl A coupled with the flexible feelers B and C is pivotally mounted upon the gear wheel D, which is continuously rotated in an anti-clockwise direction by means of a clock-driven pinion E. Mounted in a slot on the wheel D is a roller F, which, as the wheel rotates, depresses the frame G, which is pivoted at H, so that the pointer I of the measuring instrument is clamped between the frame G and the dial plate J. A ratchet wheel K, mounted on the common axis of the wheel D and the pointer I, is connected to the counting train, which has been omitted from the figure for the sake of clearness.

The sequence of operations is as follows :—

The roller F first depresses the frame G clamping the pointer I, and as the wheel D rotates further, the feeler C strikes the pointer and causes the pawl A to be engaged with the ratchet wheel K. The feeler C, being flexible, deflects to allow further rotation of the wheel D, which is now accompanied by rotation of the ratchet wheel K. When the wheel D has rotated so that the pawl and feelers are in a position corresponding to the zero position of the pointer, a fixed catch L engages with the feeler B, causing this to deflect and withdraw the pawl A from engagement with the ratchet wheel. Thus at each revolution of the wheel D, the ratchet wheel is rotated by an amount equal to the deflection of the pointer J at the instant of clamping.

A more recent modification of this device as applied to float type flow meters is described in British Patent Specification No. 172,118, and is illustrated in Fig. 23. Movement of the float rod A, by means of the linkwork in the cam plate shown, causes the lever B to move in such a manner that the angular deflection of the shrouds C is proportional to the flow corresponding to any position of the float. These shrouds are pivoted at the same centre as two similar ratchet wheels D and are coupled by a bridge piece K, with which the lever B engages. A spring E keeps the bridge piece K in contact with the lever B. Co-acting with each ratchet wheel is a spring-controlled pawl F mounted on a lever G, capable of angular oscillation about an axis common to the ratchet wheels and shrouds. Attached to each lever is a coupling-rod H to which oscillatory motion is imparted by means of a crank I driven at constant speed by means of a clock through the pinion J. Thus the ratchet wheels are rotated by an amount proportional to the period of engagement of each pawl, which depends upon the position of the shrouds. It should be noted that no fixed shroud is necessary in this device, since the pawls are oscillated instead of rotated.

The accuracy of these devices obviously depends

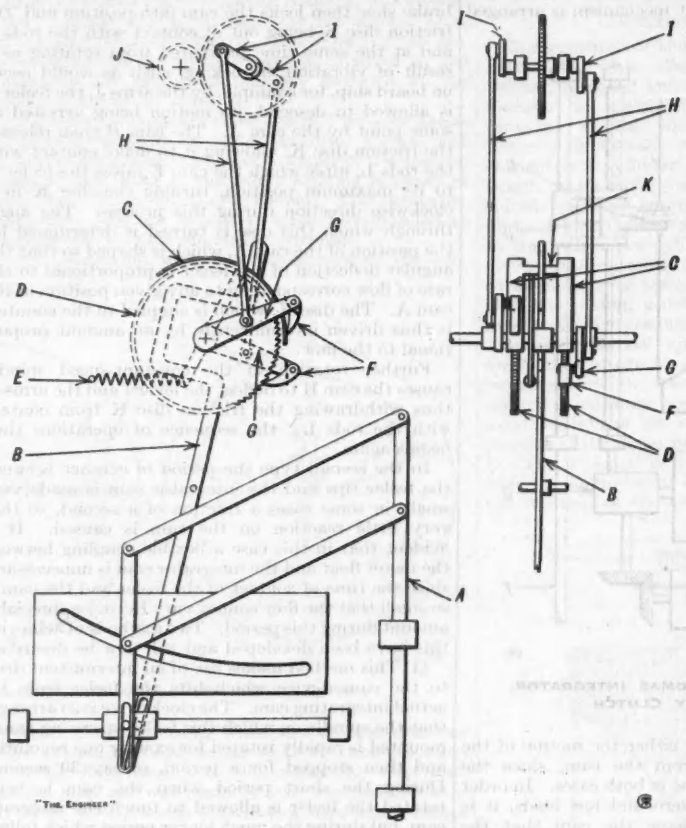


FIG. 23—RATCHET AND OSCILLATING PAWL INTEGRATOR

upon the size of the ratchet teeth, or, more exactly, upon the number of ratchet teeth corresponding to maximum deflection of the shroud. In order to increase the effective number of teeth, whilst still retaining reasonably large-sized teeth on the ratchet, two pawls offset by one-half of a tooth pitch may be used, or, alternatively, one pawl and two ratchet wheels similarly offset by one-half of a tooth pitch.[29]

DEVICES FOR PREVENTING INTEGRATION AT RATES OF FLOW BELOW A CERTAIN INITIAL VALUE.

When an integrating device is applied to a flow meter, it is necessary to arrange for integration to cease when the flow falls below a certain percentage of the maximum value, in order to prevent accidental integration at zero due to misadjustment or other cause. This is generally arranged to occur at 10 per cent. to 12·5 per cent. of the maximum flow, since, with a differentially operated meter, this corresponds with 1 to 1·5 per cent. of maximum float movement, and it would therefore be difficult, at lower rates of flow, to obtain sufficient movement and working forces to operate the device for starting integration when the flow rises above this value. It should be noted, however, that the small movement taking place in this initial range is generally enlarged by means of the cam (when such is used as a means of obtaining a linear motion of the integrator shrouds over the working range) to about 5 per cent. of full-scale deflection, in order to facilitate adjustment of the integrator. However, when the shaped limb, or float type of meter is used, the movement of the float during the initial range is half the linear value, as will be seen from reference to an earlier section of this article. It is thus necessary to cause the integrator to record a minimum of, say, 10 per cent., for an available movement of much less than this, generally about half as much, and to cease integrating at all values lower than this.

Several methods are in use, of which typical examples will now be described.

British Patent Specification No. 352,181 describes a device in which the escapement of the clock used for operating the integrator is stopped at all values of flow below the selected initial value. The cam A, Fig. 24, capable of rotating about its axis, is deflected by an amount dependent upon the flow

[29] See A. Gramberg, "Technische Messungen bei Maschinenuntersuchungen und zur Betriebskontrolle," 6. Auflage, Berlin, 1933, page 50.

by means of a suitable coupling device connected with the meter float I. Arranged to be deflected by the cam is a tappet B attached to a curved arm C, which is flexibly mounted on an adjusting arm D capable of rotation about the axis of the cam A. In contact with the arm C is a lever E pivoted at F and to the other end of which is attached a flexible strip G adapted to engage lightly with the balance wheel H of the clock escapement when the lever E is deflected by the arm C. By rotating the arm D the value of flow at which the cam A engages with the tappet B may be set to any desired value. This device is used in conjunction with an integrator of the pawl and ratchet type using fixed and moving shrouds, and the adjustment of these is such that at the point of change over from the initial non-linear to the linear range, the pawl is in contact with the ratchet for a sufficiently long period to give the correct integrated value. At this point the clock escapemen is released, so that all values above the initial range are integrated correctly. At rates of flow below the initial range, including zero, although the moving shroud does not move far enough to prevent integration, this is prevented by the stopping of the clock escapement.

It would appear, however, that unless the clock escapement is specially designed for frequent starting and stopping, this device would tend to affect the operation of the escapement adversely, especially when the flow fluctuates about the initial value.

Another arrangement, described in British Patent Specification No. 348,320, is illustrated in Fig. 25. A movable shroud A and a fixed shroud B are arranged on either side of a ratchet wheel C which is connected with the counting train D. Rotated around the same axis by means of a clock or other constant-speed drive, is a wheel E carrying two spring-controlled pawls F and G. The action of this part of the mechanism is described in an earlier section and need not be repeated.

The meter float is coupled to the movable shroud by means of a variable ratio gear train in which normally gears H and I are in mesh, but when the flow falls below a certain point the sector J engages with the pinion K, thus giving in effect a higher gear ratio, the teeth of wheel I being cut away for a section of the periphery to allow the wheel H to rotate with the pinion K. This device is primarily

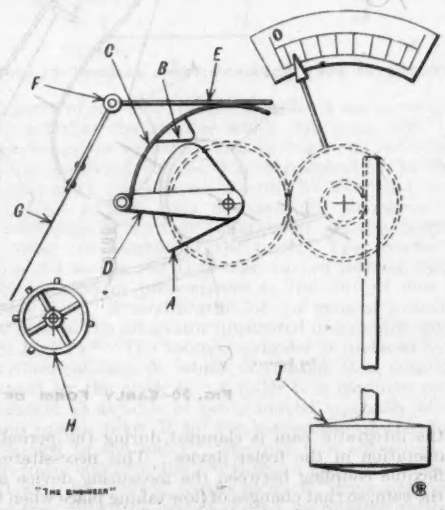


FIG. 24—DEVICE FOR STOPPING ESCAPEMENT DURING INITIAL RANGE

intended for use with the type of meter in which a linear float deflection is obtained, by shaped floats or other means, at all flows above a certain initial value below which the normal square-law relationship exists. By means of the increased gear ratio obtained in the manner just described, the reduced motion of the float over the initial range is multiplied until it causes a movement of the shroud A corresponding to the value for a completely linear scale.

In a third method, developed by one of the authors, integration below a certain point is prevented by

means of a lever device, which, in effect, increases the length of the operating surface of the fixed shroud at rates of flow below the initial value. Referring to Fig. 26, it will be seen that the fixed shroud A takes the form of a cam, the outer surface of which coacts with the rollers B attached to the pawls C to lift them out of engagement with the ratchet wheel D. The spring-controlled pawls C are pivoted at the ends of the lever E, which is rotated at a constant speed by means of a clock. The moving shroud F, operated by the measuring instrument, also takes the form of a cam, and is provided with a pin G, which, when the shroud rotates far enough in a clockwise direction, forces the pivoted catch H outwards, thus, in effect, forming a continuation of the surface of

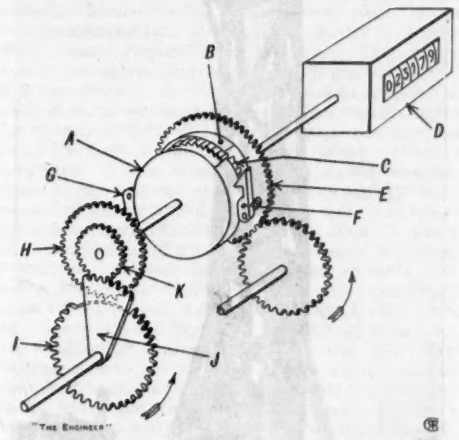


FIG. 25—ENLARGING GEAR FOR INITIAL RANGE

the fixed shroud A. By this means, integration is prevented at values of flow below a definite value, *i.e.*, that at which the pin G lifts the catch H. The position of the fixed shroud is, of course, adjusted so that as soon as the catch H is released by anti-clockwise movement of the moving shroud and, hence, of the pin G, the pawls engage during an angular deflection corresponding to the initial non-linear range.

Continuous integrators, using friction disc and wheel, require special treatment to suppress the initial range. Normally, the method adopted is to recess the surface of the friction disc from the centre to a given radius, so that when the wheel is moved to within this distance from the centre of the friction disc, contact between the two ceases, and integration is thus stopped. This method is inapplicable to the

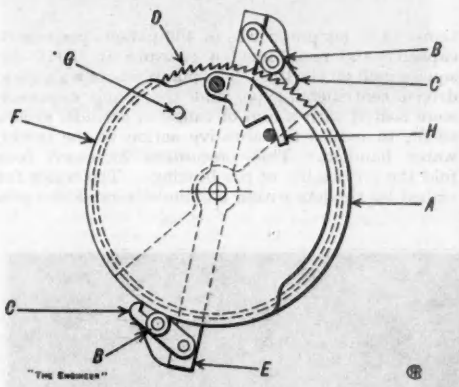


FIG. 26—DEVICE FOR PREVENTING INTEGRATION DURING INITIAL RANGE

second type of integrator—Fig. 16B—and is evidently undesirable with the third type—Fig. 16C. In these cases, a feeler is generally mounted so that as the wheel approaches the zero position, the periphery comes into contact with the feeler, which thus engages with one of the small anti-friction wheels mounted on the periphery of the wheel, and prevents rotation of the integrator wheel itself.

It is the hope of the authors that this article will present, in convenient form, a comprehensive *résumé* of the principles of mechanical flow meters, thus filling a gap existing in the literature on this subject. The authors have found that, apart from patent specifications, the available publications dealing with this matter are very limited, the most important being: "A Dictionary of Applied Physics"; Diederichs and Andrae, "Mechanical Engineering"; Gramberg, "Technische Messungen"; "A.S.M.E. Report on Fluid Meters, Part 2," and a series of articles in the *Archiv für Technisches Messen*, edited by Professor Dr. G. Keinath. Special reference to most of these has been made where necessary in the text.

The following publications on this subject have come to the notice of the authors since writing this article:—Third edition of "German Standards of Flow Measuring Devices" (*VDI-Durchflussmesser-regeln*, DIN, 1952, *VDI-Verlag G.m.b.H.*, Berlin, 1935). Short references to the various types of mechanical flow meters are given, and it is of special interest to note that it is stated that ring balances used in the chemical industry are made for a maximum differential head of 3000 mm. w.g. An article dealing with the errors introduced by the mercury meniscus in the shaped limb type of differential manometer is published in the November-December issue of *Forschung* (H. Garthe, "Untersuchung radizierender Schwimmer-manometer unter Berücksichtigung der Kapillarität des Quecksilbers," *Forschung*, Vol. 6, 1935, pages 305–309.

Sinking Eight-Foot Rotary Caissons in New York.

THE downtown section of New York City has offered a stimulating field to the foundation engineer since the beginning of the vogue for towering and massive buildings heralded the architectural transformation of that section of the Metropolis. As the weights of these structures increased it became necessary to go deeper into the ground for a satisfactory footing, and for years nothing short of the support of bedrock has been generally acceptable.

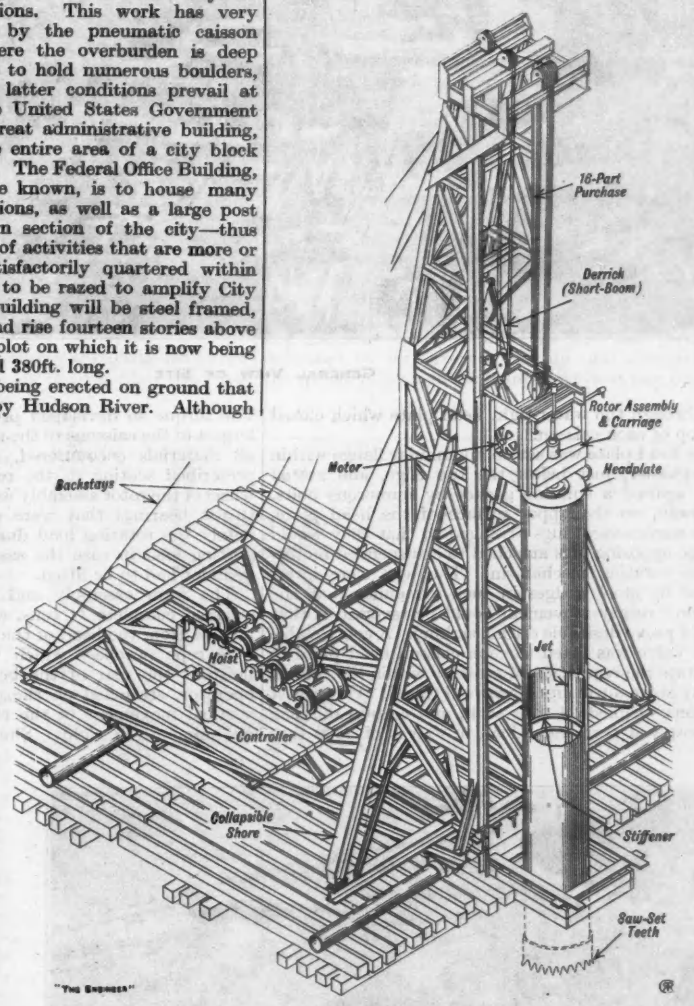
Manhattan Island's rocky backbone, except along its crest, lies beneath a variable overburden ranging from a few feet to fully 100ft. in some areas, and the problem of providing a foundation in contact with the basic ledge has been solved in different ways to meet particular situations. This work has very commonly been done by the pneumatic caisson method, especially where the overburden is deep and the ground known to hold numerous boulders, large and small. The latter conditions prevail at the site chosen by the United States Government for the erection of a great administrative building, which is to occupy the entire area of a city block bounded by four streets. The Federal Office Building, as the structure will be known, is to house many governmental organisations, as well as a large post office for the downtown section of the city—thus combining under one roof activities that are more or less scattered or unsatisfactorily quartered within an old building that is to be razed to amplify City Hall Park. The new building will be steel framed, faced with cut stone, and rise fourteen stories above the ground level. The plot on which it is now being reared is 203ft. wide and 380ft. long.

This new building is being erected on ground that slopes toward the nearby Hudson River. Although that stream is to-day about 600ft. away still the shore line of the island 125 years ago was at the south-west corner of the block in question—successive fills extending the ground surface out to the existing bulkhead line of the busy water front. The overburden that has had to be penetrated to reach bedrock is from 65ft. to 70ft. in thickness, and the formation, from the top downward, is composed on an average of 50ft. of sand with succeeding layers of sandy clay, gravel, and hardpan with a stratum of water-bearing sand, having a maximum thickness of 3ft., lying immediately next to the Manhattan schist of the bedrock. Throughout the overburden, in the lower strata, boulders are scattered, and a goodly number of these were found, during the progress of the foundation work, directly above the water-bearing sand. Boulders of considerable size were met in sinking the foundation caissons. Although preliminary borings by the Government served to disclose the depth of the rock at about fifty points throughout the site, their principal value lay in indicating that the surface of the ledge was extremely uneven. Therefore, the exact depth at the location of each foundation pier could only be approximated by the contractor and definitely established by the sinking of each caisson. All told, 112 caissons, varying from 4ft. to 8½ft. in diameter, were sunk to provide the prescribed underpinning for the building.

The Government in asking for bids left the bidders free to specify the use of either steel piles or caissons to reach bedrock. The award, however, was made to a contractor of wide experience in foundation work in New York City, who elected to bring to his aid a decidedly novel type of caisson and to develop a special plant to handle and manœuvre each of these steel tubes during its sinking. The streets surrounding the plot are generally 20ft. above the mean sea level. The basement has been excavated to El. —4, and the ground water was lowered to the latter level by means of a sump pump and then further lowered and held, by groups of well points, at El. —16. With this accomplished, the caisson sinking was taken in hand.

THE CAISSONS.

The type of caisson employed is, for all practical purposes, an immense core drill provided with a saw-toothed cutting edge, and arranged to be rotated at varying speeds while working its way down through the different strata of the ground, and while being seated satisfactorily in the ledge rock. The caissons averaged 66ft. in length ready for sinking, and any



CAISSON SINKING TOWER

excess remaining above ground when rock was reached was cut off by torch. Each of them was built for its given position in the foundation structure, and all told there were ten different diameters utilised within the limits already mentioned. The walls of the caissons, depending upon their size and the permanent loads to be carried, were either ⅜in. or ½in. in thickness, and each caisson was composed of two half-length sections united by an annular V-butt weld. Each half length was fabricated of steel plates shop welded at a plant in Sharon, Pa. Thence they were transported by railway to New York City, and hauled to the building site by motor trailers. A 28in. H-section, laid flat on the ground, served as a final assembly platform, and a stop at one end and a hydraulic jack at the other forced a pair of sections together and held them in position while the circumferential joint was being arc welded. While in that position, the teeth of the cutting edge were cut by a gas torch, and, while the metal was still heated, alternate teeth were bent inward or outward ¾in. to give the cutting edge a rip-saw set. The kerf that resulted when the caisson was descending through firm or hard material afforded sufficient lateral play to prevent jamming. The set unquestionably

entailed a heavier expenditure of power when cutting through boulders and when excavating a seating in the ledge rock, but elsewhere performance was improved to a compensating extent. The advance edge and the contact surface of each tooth was given a coating of tungsten carbide—a gas torch and Haynes Stellite composite welding rods being used for this purpose. An average of 5 lb. of tungsten carbide was expended on each caisson, and where it was possible to inspect the cutting edges when seated it was reported that there was no excessive wear. Terminating shortly above the cutting edge, each caisson was equipped with one or two water-jet discharges—caissons of 6ft. in diameter and upward having two jets, while all below 6ft. had one jet. The leads for the jets reached to the top of a caisson, where connections were made with the water-pressure line through the water-tight head plate which closed the top of each caisson.

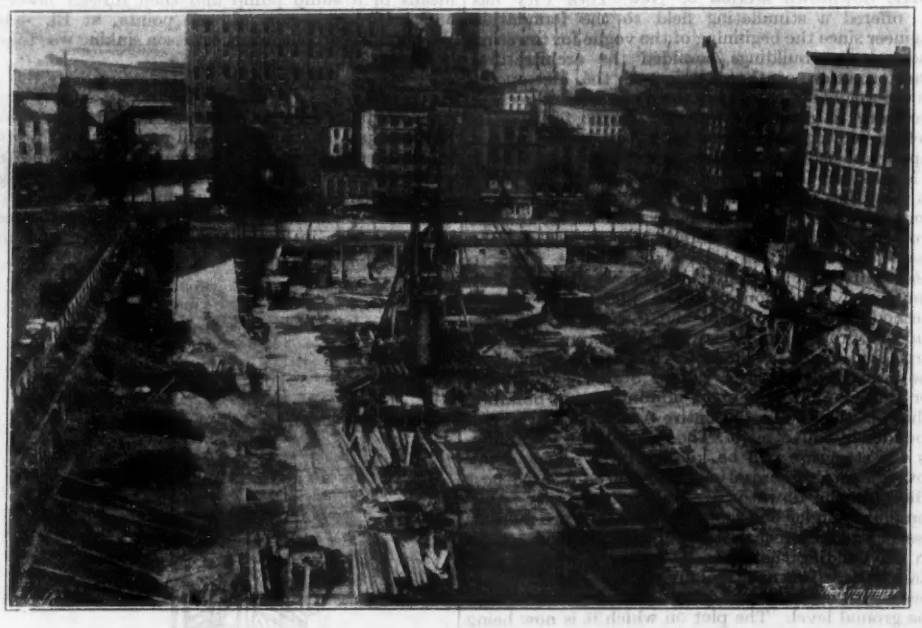
The head plate was set on an annular flange within the cylinder, just below the top edge, and seated tight against a suitable gasket by numerous bolts. Centrally, on the upper surface of the head plate, there were several lugs arranged so that they would engage opposing lugs attached to a suspended motor-driven rotating mechanism. The lugs were interlocked by steel wedges in such a manner that the caisson's rotary movement could be reversed if that should prove desirable during sinking. A controllable relief valve was fitted to each caisson head plate to facilitate the regulation of pressure within the caisson at any stage during its downward travel. The largest caissons weighed 24 tons each, and certain of them will carry a permanent load in excess of 3500 tons apiece. So much for the caissons themselves. Now for some particulars about the associated sinking apparatus.

SINKING APPARATUS.

The caissons were directed and rotated with the aid of an outfit—see drawing—that had the general appearance of a pile-driver tower. The tower was 78ft. high, of welded steel construction, and mounted upon a steel bed frame. The bed frame rested on rollers that permitted the plant, which weighed 51 tons, to be readily shifted from point to point by lines leading to a three-drum electric hoist, also carried on the bed frame platform. Stays reaching from the top of the tower to the rear corners of the platform and collapsible shores at each side of the lower part of the tower served to steady to tower during sinking operations. Guideways at the front of the tower directed the vertical movement of what is known as the rotor assembly. The rotor assembly was mounted on a car, and the principal feature of the assembly was a horizontal gear wheel that was actuated, through a worm-reducing gear, by an electric motor of 125 h.p. The speed of the motor ranged from 400 to 1200 r.p.m., and the reducing gear gave a resulting rotary speed to the caisson of from 3·6 to 10·8 r.p.m. The torque so developed proved ample to sink the largest of the caissons to the maximum depth through all materials encountered, and also to effect the prescribed seating in the rock itself. The driving wheel of the rotor assembly was mounted between two thrust bearings that were designed to take alternately the rotating load during sinking or the supporting load in case the assembly and an attached cylinder had to be lifted.

The rotor assembly and its supporting carriage weighed complete 11 tons, and that outfit was suspended from the head of the tower by a sixteen-part wire rope purchase which was led to the electric hoist at the rear of the bed frame platform. An operator, stationed on the platform, controlled the vertical movement of the rotor assembly, and had an ammeter in sight. Should the current exceed 400 ampères, a circuit breaker would come into action. However, save when cutting through rock, the rotating motor required only from 100 to 200 ampères. In practice, the ammeter was a dependable indicator of the nature of the ground being penetrated at any time, although occasional large boulders and some masses of very resistant hardpan proved deceiving before the operators became experienced. Manifestly, the operator adapted the rotating speed and the rate of descent of each cylinder to meet ground conditions from time to time, and so to make the most of favourable circumstances or to slow up when penetration was difficult.

The driving shaft of the rotor assembly functioned as the water supply line to the caisson jets, and the water was delivered to the line by a jet pump on the bed frame platform—the jet leads and the shaft, of 3in. inside diameter, being linked by flexible connections. The jet pump was of 400 gallons per minute capacity and maintained a pressure of 100 lb. per square inch on the line. The pump was of a gasoline-driven centrifugal type, and the pump clearances were coated with a film of tungsten carbide, ground to fit, to reduce the abrasive action of the muddy water handled. This precaution increased fourfold the service life of the bearings. The water furnished by the jets within a cylinder served two principal purposes; the first was to maintain an overbalancing head against ground water that could be varied to meet changing conditions, and the second was to emulsify the earth penetrated by a caisson and to force that fluid outward and upward to the ground surface. This movement of the muddy water lubricated the cutting edge, and measurably lessened the friction between the enveloping ground and the rotating cylinder. Generally speaking, the water jets



GENERAL VIEW OF SITE

SINKING A CAISSON

SECTION OF ROCK TAKEN FROM CAISSON

LOOKING UPWARD INSIDE CAISSON

emulsified and aided in carrying surfaceward substantially 70 per cent. of the material entering a caisson during sinking. Such boulders, gravel, or hardpan as then remained inside when a caisson was finally landed on the ledge rock were raised to the surface by grab buckets or mucked by hand and hoisted to the surface, the procedure employed depending upon the contact between the cutting edge and the rock, as will be explained presently.

To place a caisson in position for sinking, it was lifted upright by a short-boom derrick mounted in the upper part of the tower and then lowered into a shallow-sheeted pit immediately over the site for the pier. The deadweight of the caisson was usually sufficient to force the cutting edge far enough in the ground to produce a seal. Then, with the rotor assembly locked to the caisson head plate, water was discharged into the cylinder to fill it partly. With these preparations completed, the rotary motion was started and the caisson began its descent into the ground. As the caisson worked deeper, the head of water within it was kept high enough above the ground water to cause a continuous flow outward under the cutting edge and upward to the surface of the ground. The heaviest of the solid matter was precipitated in a convenient sump and the muddy water remaining was delivered to a nearby well, dug where convenient, from which the jet pump drew the water for recirculation. No matter how rapidly a caisson worked its way into the ground, the operator controlled the influx of the jet water correspondingly to assure the desired over-balancing head. In effect, the caisson while descending was carried on a two-fold cushion of water and compressed air. The operator had to see to it that this cushion was not dissipated whenever a caisson suddenly encountered ground of comparatively slight resistance. Although designed for external loading to help a caisson to sink, this expedient was not resorted to except in a few

BOTTOM OF CAISSON

instances where the cutting edge was only partly in contact with the ledge rock at an abrupt slope, and added weight was necessary to aid the cutting edge to clear away the rock progressively until complete circumferential contact was obtained.

In those cases where the seal between the cutting edge and the rock was such as to check an inflow of ground water the water within a caisson was gradually lowered by an electric pump let down into the cylinder. This operation was made possible by hoisting the rotor assembly out of the way and lifting off the caisson head plate. The mucking of the cylinder was then done with a grab bucket. However, if the cutting edge seal was imperfect and ground water or quicksand could enter between two or more of the big teeth, an air lock was fitted to the top of the cylinder with the aid of an adapter plate, and the cylinder was put under air pressure, so that the mucking of gravel, boulders, or broken rock could be done by pressure workers. There were occasions when it was necessary to break up sizable boulders so that they could be removed in buckets through the air lock. Plug and feathers were used to split the boulders, and the holes for that purpose were made with pneumatic rock drills, the exhaust being led through a hose to the free atmosphere above so as to sidestep the pressure in the caisson, which would have greatly reduced the efficiency of the drills. The same drills sank a hole 5ft. deep into the rock at the bottom of each caisson for inspection purposes. A total of forty-four of the caissons were thus placed under air so that the cylinders could be satisfactorily sealed to the rock with plugs of concrete poured to a height of 25ft. The other caissons, after being satisfactorily mucked, were sealed with concrete bottom plugs, 10ft. thick, the concrete being placed with bottom dump buckets. A few caissons were given an initial sealing of grout pumped into place through a hose discharging close to the inside of the cutting edge. This was done where both a head of water and a cushion of air had to be maintained just so as to neutralise the external hydrostatic pressure. The hose was passed down through the head plate and the discharge circled so as to place the grout all around the cutting edge. No matter how the primary seal was effected, each caisson was afterwards filled to the top with concrete.

According to the contractor, the rotary caissons were sunk at a rate of from 12ft. to 20ft. an hour, whereas the usual pneumatic caissons of corresponding diameters would have required anywhere from six to eight days to make the same penetration. A record was made in sinking a 5ft. cylinder to bedrock, 63ft. down, in the astonishingly short interval of 1 hour and 40 minutes. No trouble was experienced in cutting through boulders 4ft. thick, nor in cutting deep enough into the bedrock to assure a satisfactory complete circumferential seal. The cutting edge was formed in each case of a ring 18in. wide and twice as thick as the plating of the cylinder to which it was welded. The cylinders, no matter what the thickness of their walls, were stiffened by inside rings either of 1in. by 8in. plating or of 8in. channels welded to the interior of the shells at appropriate longitudinal intervals. The tops of the caisson piers are tied in with the concrete basement floor mat and the latter is consolidated with the exterior basement walls that rise to the levels of the surrounding streets.

The foregoing work has been done by the George J. Atwell Foundation Corporation, sub-contractor for James Stewart and Co., Inc., who have the general contract for the new Federal Office Building. The rotary caisson was devised by J. A. Montee, of the Atwell organisation, and adapted to meet the conditions imposed by the site in question. In the form used the equipment was the outgrowth of some experimental work on a relatively modest scale, carried out shortly before undertaking the job described. Caissons of this description may be found decidedly useful elsewhere in kindred circumstances and well worth while where a large number have to be sunk. Skill on the part of the operator is an important factor in the profitable employment of such a system, but proficiency is soon attained by a workman generally acquainted with work of this sort, as was demonstrated in the undertaking described.

The Standard-Sunbury Engine Indicator.

By E. S. L. BEALE and R. STANSFIELD.

No. I.

THE Standard-Sunbury engine indicator, developed in the Sunbury laboratory of the Anglo-Iranian Oil Company, Ltd. (manufactured by Standard Telephones and Cables, Ltd., Connaught House, Aldwych, Strand, London), had its origin in the need for an instrument which could be used even at the highest engine speeds for showing the time taken between the beginning of injection and the beginning of ignition of fuel in Diesel engines.

Apparatus commercially available before the beginning of its development was unsuitable for the instantaneous observation of effects due to rapid change of engine conditions, and, in most cases, gave only an average diagram from many successive cycles.

The success of the preliminary apparatus led to the design of units for measuring factors other than fuel quality, and the following notes describe the methods used and the results obtained. Many of the further simple applications which are possible will be obvious from the descriptions of the various indicator diagrams. An experimental engine equipped with the indicator is shown in Fig. 1.

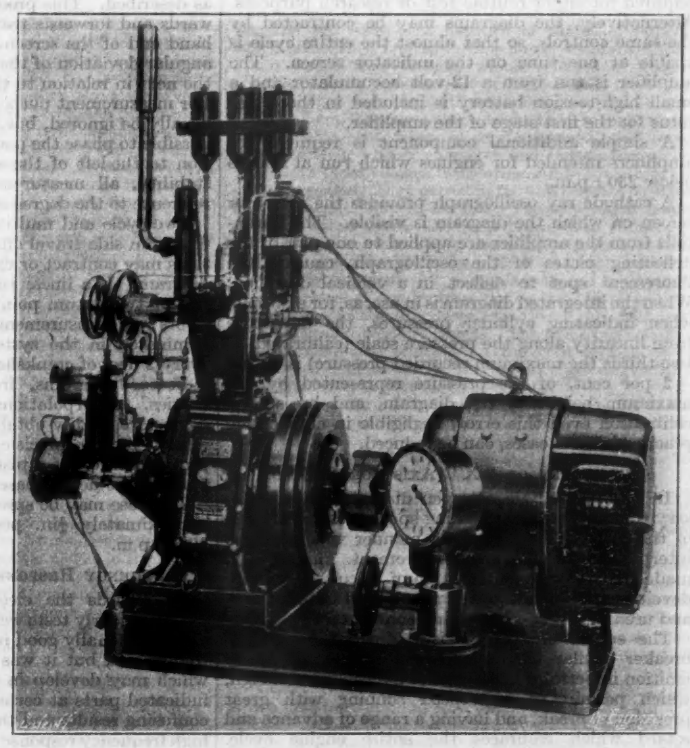


FIG. 1—ENGINE FITTED WITH SUNBURY INDICATOR

INDICATING UNITS.

Each of the indicating units used consists of a magnetic member moved by the pressure or other change which it is desired to examine, and a magnet (permanent or energised depending on circumstances) around the pole of which is wound a search coil. The system is, in effect, the reverse of a telephone receiver earpiece, thus movements of a diaphragm caused by changes of air or gas pressure generate potential changes in the winding of the search coils around the magnet, the potential at any instant being proportional to the velocity of the diaphragm. Cylinder pressure indicating units are constructed with silicon iron diaphragms, usually about 30/1000in. thick and having a natural frequency of vibration of about 42,500 cycles per second. This frequency is well above that associated even with pressure waves due to detonation in petrol engines, and there is thus no risk of error from too close approach to the natural frequency of the indicating diaphragm. The usual deflection of such diaphragms is about $\frac{1}{1000}$in., and since this is the central deflection only, it will be realised that the total mass to be accelerated is exceedingly small. Early tests with indicating units of the carbon pile type involved deflections of the order of 1/1000in. at the lower end of a pile about an inch long. Thus the pile had a mean movement of about $\frac{1}{1000}$in., and had a much greater mass than that of the simple diaphragm now adopted.

A similar unit to that used for cylinder pressures is adopted for fuel system pressures, but the diaphragm in this case has a natural frequency of the order of 60,000 cycles per second, while the unit for weak spring diagrams of suction, exhaust pipe, scavenge system, fuel suction pipe, and similar low pressures has a natural frequency of about 10,000 cycles per second. The standard fuel line pressure unit is illustrated in Fig. 2.

Fuel valve movements are indicated by applying a magnet and its associated search coil close to either the outer end of the fuel valve itself or the extension rod which transmits the spring pressure to the valve.

When the movement of a valve inside a pipe system has to be examined, it is often possible to replace the usual steel pipe union surrounding the valve by a non-magnetic housing, and the lift can then be indicated by an external pick-up unit clamped to the special non-magnetic housing without any dimensional alterations to the pipe system which might affect the behaviour of the fluid flowing inside and react on the operation of the valve under examination.

Shaft vibrations and torsional oscillations may be directly indicated in terms of angular or other dimensional movements with a simplicity depending on the mechanical design of the surrounding parts and the degree of analysis required.

VELOCITY AND INTEGRATED (DIRECT) DIAGRAMS.

It has been mentioned that the electrical output from the various indicating units is proportional to rate of change of pressure, velocity of valve lift, &c. The velocity diagrams obtained (the first differential of the more orthodox indicator diagrams) are found to be extremely useful for accurately measuring the times at which changes take place. It is, for example,

usually far easier to detect the beginning of combustion in an engine cylinder or the opening point of a fuel valve on a velocity diagram than on a direct pressure or lift diagram, as the case may be. At the same time, it is desirable to be able to inspect the usual type of diagram, and this is obtained by an electrical integration from the velocity diagram.

The electrical output from the various indicating units is applied to a resistance-coupled three-valve amplifier of a type suited to the range of frequencies involved from the lowest to the highest engine speeds, and this amplifier includes an integrating stage for converting rate of change diagrams (velocity) to the usual direct diagrams when necessary. It is fitted with all the necessary switches for changing from one indicating unit to another, and incorporates a motor generator for high-tension supply, and controls for spreading the indicator diagrams for examination of detail to an extent beyond anything likely to be required for either routine test or research purposes. Alternatively, the diagrams may be contracted by the same controls, so that almost the entire cycle is visible at one time on the indicator screen. The amplifier is run from a 12-volt accumulator and a small high-tension battery is included in the apparatus for the first stage of the amplifier.

A simple additional component is required for amplifiers intended for engines which run at speeds below 250 r.p.m.

A cathode ray oscillograph provides the indicator screen on which the diagram is visible. The potentials from the amplifier are applied to one pair of the deflecting plates of the oscillograph, causing the fluorescent spot to deflect in a vertical direction. When the integrated diagram is in use, as, for example, when indicating cylinder pressures, the departure from linearity along the pressure scale (calibrated at two-thirds the maximum recorded pressure) is within ± 2 per cent. of the pressure represented by the maximum height of the diagram, and by special calibration even this error, negligible in engineering practice in most cases, can be reduced.

Adjustment of "X" Axis for Spread.

In order to obtain an open diagram, it is necessary to traverse the indicating spot across the screen of the cathode ray tube in a manner which can be interpreted in terms of engine movement. This has been made possible by the adoption of circuits originally developed by Standard Telephones and Cables, Ltd., and used in conjunction with a control on the engine.

The engine control consists of a single contact breaker similar to that used for coil and battery ignition in petrol engines, but of a mechanical design, which permits of high-speed running with great precision of break, and having a range of advance and retard which embraces the entire engine cycle. Fig. 3 is an end view of part of an experimental engine fitted with the sweep control and degree scale unit. Rotation of the end plate of this unit controls the starting point of the diagram obtained. When the electrical circuit connected to the contact breaker is broken, a variable condenser in the amplifier unit is charged through a variable resistance and the rising voltage is applied to the second pair of deflecting plates of the cathode ray tube. This gives the horizontal movement to the indicating spot, and converts the line of pressure rise obtained from the first pair of deflecting plates (in the case of a cylinder or other pressure diagram) to a typical diagram on a base which is a function of time.

Scale of "X" Axis.

The scale of the base is determined by superimposing a wave form generated in a pick-up unit mounted near the slotted rim of a disc on the sweep control assembly. The slots are milled at 2 deg. intervals with deeper slots every tenth degree, and still deeper slots at intervals of 90 deg. By adjustment of this disc on the engine shaft one of the 90-deg. slots is set to coincide with the pole of the pick-up unit when the engine is on a dead centre position; thus when the degree scale is in use a serrated or saw-tooth line is drawn which shows the top centre by a deep serration, 90 deg. positions by similar serrations, 10 deg. intervals by slightly shallower serrations, and 2 deg. intervals by still smaller serrations. Applied to a four-cycle single-cylinder engine and driven from the crankshaft, two of these degree waves are superimposed—one for each revolution of the engine. The two scales start from any desired position in the cycle selected by the contact breaker position, but the scale from the firing exhaust half of the cycle is a little more compressed as regards degrees than that from the suction compression half, since the crankshaft travels faster during the first half of the cycle, as described. This produces a slight apparent backwards and forwards travel of the scale at the right-hand end of the screen, this travel representing the angular deviation of the shaft from one revolution to the next in relation to the starting point of the scale. For measurement purposes the deviation effects may usually be ignored, but, when necessary, it is always possible to phase the part of the cycle under examination to the left of the screen where there is precise stability, all measurements being made by direct reference to the degree scale on the screen.

Two-cycle and multi-cylinder engines give a scale free from side travel effects, although angular deviations may contract or extend different sections of the diagram. If a linear time base were used with only one or two datum points obtained from the engine, errors of measurement would occur. These are eliminated in the system described, which enables every 2 deg. of crankshaft travel to be located on the indicator diagrams, irrespective of cyclic irregularities. Interpolations to about one-tenth of a degree are readily obtainable and accuracy is limited mainly by the precision with which the exact top centre position of a piston may be determined when phasing the degree base slotted wheel.

The base may be spread as desired up to a limit of approximately $\frac{1}{4}$in. per degree of crank angle at 1000 r.p.m.

Frequency Response of Indicating System.

As regards the electrical characteristics of the indicator, early tests were made with a system having an exceptionally good response to high as well as low frequencies, but it was found that vibratory effects which may develop in the cylinder gases and other indicated parts at certain periods in the cycle led to confusing results and therefore, for general work, the high frequency response has been deliberately reduced.

In consequence of this limited and known reduction, such frequencies as those associated with detonation, while still recorded, are somewhat reduced in amplitude and thus have less tendency to confuse the broader effects regarding which data is generally required. The special units can, of course, be substituted for tests in which the maximum high frequency response is wanted.

It might be thought that the use of a magnetic system in the indicating units would introduce hysteresis effects, but it should be remembered that changes in the magnetic field strengths are small and thus the width of any hysteresis loop is reduced to an extent much too small to be measured.

Calibration.

As regards calibration of the various scales, there are many obvious methods, the one selected depending on the particular unit in use.

For cylinder pressure measurements it is usually sufficient to apply a maximum pressure gauge to the engine in place of the indicating unit and to take a reading from this under given engine conditions, bearing in mind that a maximum pressure gauge will give a reading more or less equal to the highest pressure reached during the succession of cycles for which it is applied.

Observation of the maximum height of the indicator diagram under the same engine conditions gives the required calibration and, assuming linearity, an error of not more than about 2 per cent. of the full pressure will be made at any part of the diagram.

Alternatively, the indicating unit may be connected to an air vessel and pressure gauge external to the engine and a small bore indicator valve inserted between the unit and the air vessel. Hand opening of the valve first to admit pressure air and then to vent to atmosphere gives a line on the oscillograph screen, the maximum height of which equals the air vessel pressure. A complete calibration can be made in this way and generally such a valve can be inserted in the system and used while the engine is running, in any case where an atmospheric datum line (not obvious by inspection) is required for reference. Temperature effects on the indicating units can be neglected in most cases, as it is found that, at least in Diesel engines and petrol engines of the vehicle type, the diaphragms operate between 100 deg. and 180 deg. Cent. and that the differential expansion between the casing and the magnet, which alters the air gap and thus the diagram height, is negligible. Throughout the development of the instrument every care has been taken to check its behaviour and while it is believed to give superior results to most other designs as regards accuracy, it is preferred not to overstate this, but rather to urge users who require extreme precision to satisfy themselves by making their own calibrations. Such calibrations must obviously be made dynamically and not statically, whatever the type of indicator used.

In the case of fuel valve lift diagrams, &c., it is generally sufficient to run the engine at a load and speed at which the valve is seen definitely to reach a stop and, knowing the maximum possible lift, to assume linearity.

A more exact calibration can be made by making two or three tests with the maximum lift adjusted to different values between each so as to obtain a calibration curve which will be found closely to approximate to a straight line unless very large diagrams are drawn, obtained with small air gaps between the pick-up pole and the valve.

Fuel system pressure calibrations can be made most rapidly by testing the fuel valve for static lift pressure, and then, using the valve in the engine, indicating the fuel system pressure close to the valve with the fuel supply adjusted so that the engine runs slowly and with the least possible fuel. The fuel pressure diagram then shows clearly the opening point of the valve and direct measurement of height at this point gives the fuel pressure scale.

These calibration methods are essentially practical, and have been justified by more elaborate tests under laboratory conditions.

In general use, it may be assumed that the horizontal and vertical scales are strictly at right angles. Sections of diagrams traced on the sharply rounded edge of the screen are not used, but phased for measurement to the almost flat central part of the oscillograph. Tracings may be made with reasonable accuracy, and, if desired, photographic records may be taken. When the standard oscillograph with green fluorescence is in use, time exposures ranging from a few seconds to 30 are needed. If an oscillograph tube with blue fluorescence is used, the exposure may

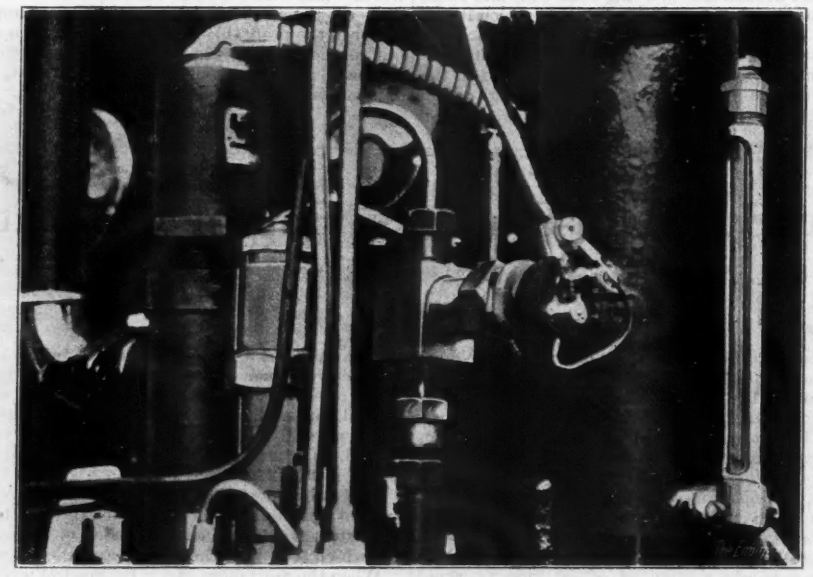


FIG. 2—SUNBURY PRESSURE UNIT ON FUEL LINE

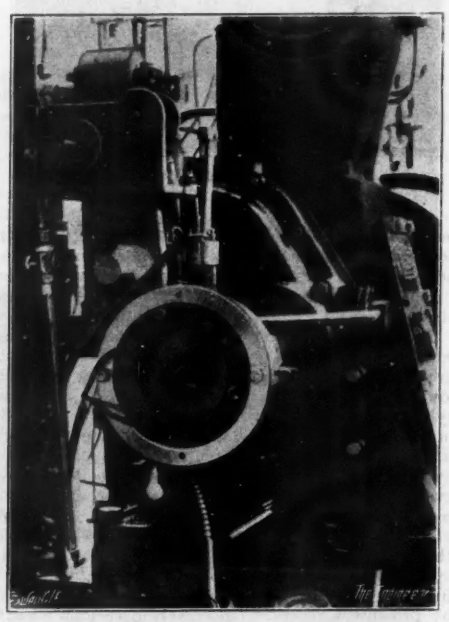


FIG. 3—SWEEP CONTROL AND DEGREE SCALE UNIT

often be reduced to show from one to only a few successive cycles, the number depending on the "writing speed" of the fluorescent spot which traces the diagram. Oscillograph photography invariably suffers from local over-exposure of any part of the diagram drawn at a relatively slow writing speed compared with the maximum on which the exposure has to be based.

When the greatest possible accuracy of calibration is required, notice must be taken of several factors which can usually be ignored. No oscillograph is quite perfect as regards rectilinearity of the "X" and "Y" axes over the whole of the screen; the screen is slightly and necessarily curved; the curvature is never mathematically exact; and each tube has its own and other slight departures from perfection. For precision it is therefore best to make the pressure or other calibration of the indicating unit on a selected portion of the screen, preferably an inch or two from the left-hand end of the horizontal axis. Such calibrations should be made with the various controls set as they will be used for subsequent tests, and the voltage of the low-tension battery should be checked both during calibration and while making later measurements. Instead of examining the whole useful diagram as it appears on the screen, the contact breaker on the engine shaft should be phased so that it brings each ordinate to be measured substantially to the position at which the calibrations were made. The "X" sweep should also be short-circuited, and if the resulting trace (an approximately vertical line of total height proportional to the maximum cylinder pressure, valve lift, &c.) is not quite at right angles to the "X" axis allowance should be made for this when ueasuring. These precautions are of an obvious character, and present no real difficulties, and it is emphasised that far more serious errors arise in other seemingly accurate indicators than those likely to occur when the oscillograph indicator is used without special precautions and the entire diagram on the screen assumed to have a strictly linear height scale and to be on rectilinear axes.

The errors associated with cathode ray tubes have been dealt with rather in detail, even though they are negligible in ordinary indicating, because there has been a tendency recently to claim a perfection which has not been attained. The cathode ray oscillograph, new to the mechanical engineer, but not to the physicist, is an immense improvement on anything hitherto available for practical test bench use, but this scarcely justifies some of the statements which have been made regarding its absolute precision.

Cylinder Pressure Indicating Units.

Reverting to the design of the cylinder units, the diaphragms are mounted at the end of a small bore, about 1in. long. Few commercial designs of engine can be adapted to take indicators with the pressure member directly in the surface of the combustion space, and usually the minimum practicable distance from the cylinder proper to the diaphragm is appreciable.

This bore of the passage to the air chamber and the diaphragm beyond it introduce a lag in the pressure diagram equal to the time taken for sound to travel through the passage and air chamber to the diaphragm under the conditions prevailing at the moment of observation. An approximate correction (about 100 micro-seconds for a 1in. length with the associated air chamber) can be made for this effect, although it is rarely of practical importance.

Owing to the small movement of the diaphragm, appreciable build of carbon may be permitted in the orifice before the diagram shape is affected, and even in the worst case experienced it has been possible to use the cylinder unit continuously for ten hours in an engine running at 1000 r.p.m. before the velocity diagram shows appreciable lack of high-frequency response. Choking is at once obvious to the operator, and cleaning and reassembly takes only a few minutes. Units have been used without serious effect on results until only about an hour before the bore was so badly choked that the carbon at the inner and under the diaphragm had to be drilled out. In many engines a running time exceeding 120 hours is possible without cleaning the cylinder unit.

It is unusual for petrol engines, except those made specially for experimental purposes, to be designed with an opening into the cylinder to take an indicator. In such cases a short small bore steel pipe, about 1 mm. bore, can usually be brazed or welded into the lower part of a sparking plug body and fitted at its outer end with an adaptor to take an indicating unit. The phase lag is thereby increased, but indicating becomes possible in standard engines and gives results of considerable value. Detonation can be detected before any audible signs are present, and the velocity diagram shows this incipient detonation as a high-speed vibration breaking away from the combustion line just before the maximum pressure point is reached at which the rate of pressure change is zero. Under heavier detonation, this vibration starts earlier, until, with heavy audible detonation, it has advanced to the position where the pressure is rising at its maximum rate.

Often there is sufficient electro-static pick-up from the ignition system of a petrol engine to give a small well-defined line on the pressure and velocity diagrams at the moment when the spark passes, but, when this is not the case, the moment of sparking can be determined by holding a primitive pick-up coil of five or six turns of flexible cable near to the plug and coupling leads from this to one of the sockets on the amplifier provided for indicating unit connectors. Certain powerful ignition systems may involve screening of the plug leads if the indicating unit is very close to such leads, but this does not present any difficulties.

The standard indicating units are designed for use with leads up to about 16ft. long. Greater lengths than this alter the response to the highest frequencies, but this is usually unimportant, except for special research when use may need to be made of the high-frequency response calibration.

When it is required to use much longer leads for the sake of locating the amplifier in a convenient and more remote position, units exactly similar to the standard units, but with rather fewer turns on the search coils, are used. In this way the frequency response up to the limit of useful frequencies can be maintained by compensating for the electrical capacity of the leads by means of the self-inductance of the search coil up to any required length of lead.

Carbon-pile and similar pressure-indicating units of relatively high resistance may be very seriously affected as regards response to high frequencies by capacity of the associated leads.

Critical Speed Determination.

Preliminary tests have been made with a view to developing a complete method for examining torsional critical speeds, and there is clearly no difficulty in applying the same pick-up unit as is used for the degree base to give direct readings of critical speeds and the angular deflections. This method has obvious advantages over systems which give either accelerations or velocities of the vibrations, these involving double or single integration respectively if angular displacements are required.

(To be continued.)

The Organisation of Transport.*

By FRANK PICK.
(Vice-Chairman of the London Passenger Transport Board).

The London Passenger Transport Board came into effective existence on July 1st, 1933. It represents the amalgamation of 165 undertakings, or parts of undertakings, previously conducted as separate entities, even when associated together for certain objects or services.

To fit all these independent and irregular pieces together into some ordered whole is almost like a jigsaw puzzle, and after two years it cannot yet be said to be wholly assembled. To illustrate the magnitude of its operations, in the year ended June 30th, 1935, the last completed year of the Board, it ran 534 million service car miles over a combined route mileage of 2770 miles; it took its full share in the carriage of 4129 millions of passengers dealt with under the London Passenger Pooling Scheme. The measure of the service rendered by the Board is best reflected in the 56 car miles per head of the population which it ran, which, with the 29 run by the main line railways upon suburban services, making 85 in all, sets a standard not exceeded, not even approached, in any other metropolitan city. The measure of the traffic movement is 377 journeys per head of the population, which, with the addition of 58 for the main line railways, making 435 altogether, is again the highest recorded so far as is known; proving what must be accepted as a principle, of urban transport anyway, that facilities beget the traffic that uses them. The area which the Board serves is 1986 square miles, of which 1551 square miles, or roughly 80 per cent., is its exclusive territory. The population of the area is estimated at 9,500,000. It is thought to be the largest metropolitan aggregation of population in the world, the only doubt being in connection with New York, which, if certain portions of New Jersey were added, might then be greater.

It stretches roughly 32 miles to the north and south of the centre, and 25 miles to the east and west. Certainly there are territories beyond its boundaries which look towards this London, even important towns in themselves like Brighton or Southend, which could not have grown to their present size except for their proximity to and dependence on London. Some day there may be a further review of this problem of the proper area of the metropolis, and such review is bound to lead to an extension of the present boundaries. There is a sense in which London and the Home Counties so-called represent a social, economic, even geographical unity which may require and demand single treatment. These speculations are for the future. They are mentioned to lead up to a point of principle, namely, that an aggregation of people in a single social, economic, geographical unit requires a single organisation for the discharge of each one of the many objects or functions which it embraces.

That higher organisation which co-ordinates all these functions into a whole is left at this stage as being almost too debatable for treatment. But at the root of the matter of London passenger transport is this question of unity. What is the London Passenger Transport Area, and for what does it exist? In area it is little more than a fiftieth part of Great Britain; in population it is just a little more than a fifth; in rateable value it is about one-third; in wealth and power it is a still higher or greater proportion, maybe almost half. Yet size, numbers, riches are not any real criterion of usefulness or effectiveness, for without organisation they cannot be applied to achieve any result, and without adequate transport they are merely awkward and dangerous accumulations. It is the integration of all that is contained in London to express some idea or aim or purpose that alone gives value to the masses of which it is composed, and this integration only becomes possible with a system of local passenger transport which allows free movement of the people so that each may act where he or she is wanted, so that each may act now here, now there, as may be required of him or her. Transport creates economic values by putting the right man or woman in the right place. It is therefore correct that the first function of a metropolis to be organised and established as a unity should be its local passenger transport. Without it there would be no chance whatever of ever looking at London as a whole. It is vitally necessary to try to grasp London as a whole and give it form and order, and, as it were maybe foolish ambition to attempt too much, it is perhaps best to proceed piece by piece or rather function by function, and of the several functions to be explored and defined transport is one, and of transport local passenger transport is a major and lively part. This is the sphere of influence and activity of the London Passenger Transport Board. Water, gas, electricity are services or supplies requiring strict business and technical administration. Sewage is another service. These are all susceptible to similar treatment.

Even the London Passenger Transport Board is not without its flaw. The suburban services of the main line railways representing 1023 miles of route, running 273 million car miles and carrying in whole or in part 547 million passengers, are still dispersed in the hands of four amalgamated companies. These services represent in car miles 34 per cent. of the whole, or in passengers 13 per cent. of the whole. True, there is a standing joint committee of the Board and the four companies, to consider their mutual interests and to endeavour to settle any conflict that there may be between those interests. Yet that is not the same as a welding of those interests into one. For the main line railways, the suburban traffic of London is a minor element in their traffic at large, except perhaps in the case of the Southern Railway and a conflict of this minor element with the major element is not always escapable. Thus, a strain or twist creeps into the organisation, and it is not altogether of one piece as it should be. It becomes dependent upon goodwill. It is there now, but will it always be there? It is impossible not to ask the question. Perfection is a dangerous pursuit, so possibly it is well to accept the flaw with a good grace.

At the moment, however, the task of dealing with local passenger transport as a unity, as a specific function of this metropolis, is proceeding under favourable conditions. The central government has taken a decisive interest in its fulfilment, and has agreed to support an expenditure of £40,000,000 for the enlargement and improvement of the means employed for its discharge, and this money will be largely expended on measures for the physical co-ordination of such means. It is, therefore, fitting and appropriate at this moment to survey the devious ways in which this task has been approached in the past, and the stage which has now been reached.

The first suburban railway was built in 1836 and ran from Spa-road, Bermondsey, to Greenwich. It was the consequence of the invention of the steam engine. It was the precursor of a network of suburban railways which established new townships out of stagnant villages round about the stations, which sent their working population daily into and out of London. In these days these villages were places like Clapham, Brixton, Streatham, Balham, Tooting—places which have become almost indiscernable, yet when closely examined still reveal traces of their village character and independence. In these days these villages transforming into townships are still represented. They persist in the outer spaces as places like Feltham, Ashford, Bedfont, Yiewsley—soon maybe to suffer submergence like their prototypes. The horse bus was first organised as a means of transport in 1829, and soon began to fill up the interstices of the nucleated railway development, by occupying all the main roads within a range of 4 miles from the centre. In those days places like Richmond or Hampstead were the great fresh air holiday and pleasure resorts. The horse bus solidified the inner suburbs and settled the core of London—a core about 8 miles across, but steadily growing until it corresponded closely to London County.

The tram started as a horsed vehicle in 1861 and became a competitor of the bus and accelerated the process. In 1901 the tram was converted to electric traction and set out upon a forced expansion with the aid of subsidies from the local rates.

The underground railway system had commenced as a girdle of shallow railways in 1863, but had hardly differentiated itself from the general suburban railway system until, with the coming of electric traction, the deep level railways in tube construction were built, beginning in 1890. Then, passing through various phases of expansion, there began an alternative system of railways, with distinct characteristics both of service and fare, stretching out to distances of 12 miles or so from the centre and stimulating the building of houses, so that the effect of this super-imposition of one railway system on another must be the complete occupation of land that is not definitely secured against exploitation within this 12-mile zone. So the solid core of London is enlarged maybe more than is healthy or advantageous, and tends to stretch to a bulk 25 miles across, corresponding closely to the Metropolitan police district.

Electric traction has, in turn, come to the aid of the main line suburban railway system, and by its greater efficiency opened up a still wider field for suburban growth, in colonies of houses round stations ever further and further out up to distances of 25 to 30 miles from the centre; so that the immediate sphere of influence of London is now an area about 50 to 60 miles across, corresponding fairly closely to the London Passenger Transport area.

The internal combustion motor ousted the horse in the years 1906 to 1911, and the motor bus and coach now cover all roads of any traffic significance throughout the London Passenger Transport Area, and even beyond. The effective range of the express services by coach compares nearly with that of the electrified railway suburban services. These services have occasioned a fresh ribbon development along the main roads leading out from London, which has been condemned indiscriminatingly because it was misunderstood. The policy of constructing a new system of arterial roads dates from 1920. These

* From a paper read before the Royal Society of Arts on Wednesday, December 11th.

roads opened up entirely unspoilt country. They commenced almost houseless and their beribbonment was therefore conspicuous and discouraging. The fault was not so much with the development itself, as with its extravagant and wasteful shape, owing to the absence of any real plan.

The motor car is planting villas sporadically over all the countryside without any regard for a reasonable economy in the employment of land, so that the distinction between town and country around London is almost wholly breaking down. This is an even worse abuse than beribbonment, but has attracted less contumely and criticism. There are now about 415,000 motor cars licensed in London and the five Home Counties, or one to every twenty-seven people resident in these areas. All but a small proportion of these motor cars must operate in and about London. They represent a menace to communal transport. They cause an abuse of street accommodation. They are the main ingredient in congestion, and it is questionable whether London can economically support them, when road widenings may cost up to £1,000,000 per mile and the added space may primarily be used for waiting vehicles.

The varied patterns created by the changing means of transport were not brought into relation one with another until the establishment of the London Passenger Transport Board in 1933. It would be unfair to overlook the efforts made by the Underground Group of Companies to remedy the divergencies from 1904 to 1933. As a voluntary and private venture, it was extraordinarily public-spirited and courageous, and it set the example and created the circumstances in which the London Passenger Transport Board became possible. These patterns of transport constitute the indispensable framework upon which London must be built. Much care and thought and skill is required for their execution. They cannot be looked upon as just a railway line, a bus route, a tramway, or whatever it may be. For in themselves they have little significance. Their significance comes from what is eventually hung upon them—parks, open spaces, schools, places of entertainment or amusement, shopping centres, and predominantly housing. So some other reviewer of London might prefer not to talk of transport patterns but to talk of patterns for parks and open spaces—a green belt; patterns for schools—an educational system; patterns for cinemas, theatres, shops; patterns for housing. What is called town planning in fact. So far as London is concerned all these patterns are affairs of shreds and patches. Any comprehensive pattern covering the field is wanting. London is not planned at all, only its bits occasionally. That is what complicates the problem of planning for transport. There is no assurance that the other functions which London serves will be planned in harmony. At this present time there are proposals for the electrification of railways in East and North-East London. In large part this is aimed in making good the neglect of the past, and the area to be served is already over a large extent fully developed in the patternless fashion of the past. But the proposals go somewhat beyond and bring electrified train services into areas still undeveloped. Since they were announced there has been discussion upon the location of the green belt, and this is still undetermined and unprotected. There has been a suggestion to sterilise a vast expanse for an aerodrome, but again no conclusion reached upon it. In all probability the transport facilities will be completed and in operation before any settlement is agreed, and in all probability some part of the facilities will represent a waste of money and involve further expenditure for their adjustment. On the other hand, the London County Council have purchased 434 acres at Chigwell for a cottage housing estate, which means that transport facilities and traffic are in this case aptly complementary.

These patterns of transport again are conditioned by factors of time and cost. Speed is a function of time; the fare is a function of cost. There is a limit to the time which can be spent in journeyings to and fro for daily work, so that the magnitude or scale of an urban transport system turns upon the average speed of operation. At twelve miles per hour, which may be taken as the average speed of street transport, a six-mile range would appear to fix the limit for any mass movement. Cities, therefore, based on tram or bus or trolly cannot expect to grow readily beyond a radius of six miles from the centre. At twenty-five miles per hour, which may be taken as the average speed of local railway transport—whether underground or surface—the limit is expended to some range of twelve miles, which fairly corresponds to the built-up zone of Greater London. Main line suburban trains running out express to stations beyond this twelve-mile zone will build up colonies around their stations, and will establish a unity of interest with what, at first sight, appear independent towns at long range. Brighton has a daily traffic in and out of London estimated at 10,000, and Southend a corresponding traffic estimated at 20,000. The more leisured workers and the half workers will comfortably spend an hour each way on travel.

The prevailing fare charged also governs the magnitude or scale of an urban transport system. At 4d. the volume of traffic diminishes; at 6d. per journey the mass movement is ending. Traffic is tailing down to volumes that will not justify a regular interval service. For the true characteristic of an urban transport service is that a time-table is not wanted. The trains must be so frequent and the intervals so regular that reference to a time-table is idle. The question, therefore, is how far a passenger can reasonably expect to be carried for 6d. The ordinary fare is no real index. Workmen's fares offer a return journey for a single fare. Special day tickets are usually on sale on the same basis. Season tickets for the longer distances may be in issue which for twelve journeys a week work out at an equivalent or even a less rate of fare. At about a halfpenny per mile the twelve-mile zone is again indicated.

Both so far as speed and fare are concerned the importance rests in a balanced provision. If in any one direction speed or fare is exceptionally favourable, then an unwholesome and unfair stimulus is given to expansion in this direction and the development of London is distorted. For example, when Liverpool-street Station was built a large clearance of working-class houses was necessary to secure the site, and Parliament placed upon the Great Eastern Railway the obligation of rehousing the displaced tenants. This was not practicable except at some distance out on the railway, and so Parliament added a further obligation to carry the workmen at special cheap fares of 2d. The fares were available for all, and the dense workmen colonies of Walthamstow and Tottenham sprang into existence. These districts were speedily overbuilt in monotonous fashion and have scarcely recovered from the evil effects now.

Unluckily traffic considerations are partially subordinated to other considerations which still retain elements of competition. Local authorities vie with one another in seeking expansion. Housing programmes have a tendency to settle and concentrate in unexpected areas. A vacant land, vacant because the transport facilities are inadequate, seems especially attractive. There cannot be a competitive basis to the economic and intelligent planning of a metropolis. The principle that competition is bad is now accepted and applied to transport. How long must London wait for its acceptance and application to the other functions of a healthy growing organism? There is urgent need for parallel treatment if the jumble of glass in the kaleidoscope is to take on those lovely and amazing patterns that are so much admired.

It is not surprising, therefore, to find that much argument and dispute has been awakened by the programme of works in respect of which the Government is to assist in the raising of £40,000,000. Districts not included in the scope of the works are clamorous for an enlargement of the programme. Even those to be served are eager for a more generous treatment. In transport there is never satisfaction. There is always something more required. Yet the expenditure of £40,000,000 in five years is an enormous undertaking if it is to be well spent. The mere labour of devising and executing the works is prodigious and must absorb all the persons skilled in them for the period. When the works are completed and opened for traffic they will demand an additional 120 millions of passengers for their support, and as an immediate consequence an additional population of 750,000 persons. Where are these passengers and people to come from and how quickly will they arise? If the years of fructification should be prolonged the programme will be a burden upon the transport system as it now exists. Present passengers will have to bear this burden until the future passengers come in to relieve them. How important, therefore, is the initial choice and planning of the programme. Only those expert in the study of transport developments and tendencies can fairly or reasonably gauge the prospects of this or that work and the priority which they should enjoy in a considered programme. A miscalculation has the effect of retarding or preventing a continuous programme and of calling for a greater patience than that which some must have if any ordered programme is to be pursued at all.

There is nothing, however, more strange in transport than the fact that facilities create traffic. Passengers arrive out of nowhere as it were. When the coaches were put on the arterial roads running out of London, it was thought that they would merely displace railway suburban traffic. This proved quite false; an unexpected traffic grew up along the roadside so long as it could be taken where it wanted to go into the heart of London. Regulation descending upon the system of coach routes so built up, excluding them from the centre and limiting their stops, destroyed over a quarter of the traffic. It did not reappear anywhere else. It went just as mysteriously as it came. The Board has opened two new interchanges between its railways, one at Holborn between the Central London and Piccadilly Lines, one at Monument between the City and District Lines. At Holborn there used to be an exchange of traffic of the order of 1,460,000 passengers per annum; it is now 9,800,000, an increase of 620 per cent. in two years. At Monument there was no exchange, now there is an exchange of 5,900,000 passengers after two years. The traffic has come from no one knows where. It has been a suppressed traffic waiting to realise itself. The outward shift of population is accelerated pointing to longer daily journeys; the rides taken per head of the population is again increasing. Within limits, therefore, an optimistic outlook is justified. The facts seem always to improve on the estimate. Yet the expenditure of £40,000,000 looks to an increase in population of 750,000 for its support; and this at a time when the demographists assert that a falling birth-rate, even though helped by a falling mortality rate, will lead to a stationary population within the present censual period. Allowing for immigration, for the mass of London exerts its spell upon the whole country, it will be a hard matter to create any such increase. A birth appeal society may be required to assist in the labours. Yet somehow one may have a confidence that the facilities will create traffic. In this expectation the London Passenger Transport Board must go forward. But these prophecies of the scientific observer are a warning. The various forms of transport must be co-ordinated and what development remains must now look to the end. The present programme and the one to succeed it must have as their object the final balancing of the present complex systems of transport to secure an optimum result. The railways must be pieced together and supplemented so that their expensive facilities are filled as full with such traffic as they can fairly and reasonably accommodate. It is an intriguing and arduous problem. At the end, the patterns of local passenger transport should be clear and understandable, and the distant observer will be able to look at them with an æsthetic satisfaction.

Underneath all the commercial activities of the Board, underneath all its engineering and operation, there is the revelation and realisation of something which is in the nature of a work of art. All the patterns of transport contribute to it, but it transcends them all. It has the mystical and spiritual attributes that are found in the mount of vision. It is, in fact, a conception of a metropolis as a centre of life, of civilisation, more intense, more eager, more vitalising, that has ever so far obtained. Out of the mere pressure of all these millions of people one upon another, a pressure which transport encourages, some new whole may arise, which, like the city state of ancient Greece, the state in which all its citizens were able to take part in its affairs, may have significance as a stage in the evolution of society on this spinning globe, the world, a metropolitan state which can organise the activities of its millions of citizens to a common end and purpose more liberal, more worth while, than that which could come from anything smaller. The breaking of statistical records for population, traffic movement, congestion, speed, safety, are all isolated and insignificant endeavours unless they are incidental to the conception of a life and civilisation on a greater and more splendid scale. There is the sphere in which it is not a breaking, but the establishment of a record. Only if that is the case is all the disorder and struggle of London justifiable or even tolerable. The London Passenger Transport Board is, or will be, a work of art.

Power Supply of Dunedin, N.Z.

AN undertaking upon which the Dunedin City Council, Otago, New Zealand, has embarked at Waipori, in following out a scheme of replacing the existing pipe line with a tunnel over 2700ft. in length, is one of great magnitude. At Lake Mahinerangi, which conserves the large quantity of water required to keep the power-producing plant operating at full strength, one of the stations is situated as shown in an engraving on page 622, but the water which supplies the lower power-house, the main source of the city's electrical energy, has to be conveyed a considerable distance before it reaches the point at which it is used. At present it is picked up from the Waipori River below a dam and travels through a tunnel, 4700ft. long, before it reaches a surge tank, where it joins the pipe lines that carry it the remainder of the distance to the turbines.

So vital a part of the power scheme do the pipes form that, were they to become inoperative Dunedin's main source of power would be cut off, and some alarm was caused when five years ago, owing to an earth movement, all of the pipes slipped nearly 6in. down the steep hillside on which they are laid. As the occurrence constituted a serious threat to the safety of the existing scheme, the City Council decided that the pipes should be replaced by a pressure tunnel through the hill, driven at so great a depth that it would be in no danger of being affected by the earth movement above. It is upon this undertaking that workmen have been engaged for several months past, and they have progressed so far with their task that, of the total length of over 2700ft. of tunnel which has to be driven, only 300ft. remains to be completed. The contract, however, also includes the laying in the tunnel of pipes 6ft. 9in. in diameter, and the surrounding of them with a layer of concrete 1ft. thick. In the new scheme it has been possible to use a portion of the existing tunnel, and at a point in its course it will be joined by the new tunnel, 650ft. in length, providing a connection with a new surge chamber, which has already been constructed. At the surge chamber the main tunnel, which will be 2100ft. in length, begins its descent to the power station. This tunnel, which is at three different levels, has a total fall of 750ft. The surge chamber, which is an important detail of the new scheme, is also one of its most interesting features. Shaped like a wine glass and 65ft. in depth, it has a dual purpose, for not only will it provide a safety valve for the back pressure of water when the turbines are shut down at the power house, but it will also provide a temporary source of water to meet any sudden increase which may be desired at the station.

The Council has had the misfortune in carrying out the scheme to encounter an obstacle which has figured largely in its recent discussions. The early investigations indicated that the whole of the tunnel would be driven through solid rock, but the actual experience of the contractors has been that soft material has been encountered over a considerable portion of the course of the tunnel. While timbering has been necessary, inconvenience has also been caused by a seepage of water from above. The Council has been assured, however, that the difficulties which have been encountered will in no way impair the ultimate stability of the scheme.

SIXTY YEARS AGO.

FROM the report of our representative who attended the Smithfield Club Show of 1875 we gather that the weather in London during the early part of December of that year was bitterly cold and windy. In other parts of the country the meteorological conditions were the subject of comment and the cause of much discomfort, anxiety and even of disaster. July and November had been exceptionally rainy months. In the South Staffordshire district the efforts put forth by the Mine Drainage Commissioners had proved insufficient to prevent the steady rise of water in the mines. Writing in our issue of December 10th 1875 our local correspondent described the position, particularly in the Bilston area, as grave and even critical. Already one seam was 8ft. under water and soon, it was prophesied, no minerals would be available for mining in the South Staffordshire district except the insignificant amounts which lay at less than 30 yards below the surface. In London the Thames had overflowed its banks causing much loss and suffering. Popular opinion, too, attributed to the weather a series of half a dozen colliery explosions which occurred in various parts of the country within a few hours of one another. It was commonly believed that a sudden local diminution of barometric pressure resulted in the liberation of fire damp in the mines. In a leading article we did not dispute the general accuracy of that conclusion but we urged that steps should be taken under proper scientific control to verify it and study all its implications. Two of the explosions occurred in the South Wales district, one, at the Duffryn Pit, New Tredegar, involving the loss of twenty-three lives and the other, at a bituminous colliery 6 miles from Cardiff, being responsible for the death of twelve miners. A third and still greater explosion occurred at a Barnsley, Yorkshire, mine.... The belief that a fall in the atmospheric pressure was accompanied by the risk of explosion in coal mines died a hard death. It is now more usually held that a rise of pressure acting on the surface closes up the cracks and forces the gas trapped in them into the mine workings. Sixty years ago the ventilation of mines was for the most part achieved by a method which to us to-day must seem to have invited explosions whatever the height of the barometer. In Great Britain the almost universal method consisted in rarifying the air by means of a furnace at the foot of the upcast shaft.

Rail and Road.

THE work of clearing the landslide on the Southern Railway near Winchfield, Hants, which occurred on November 17th, was carried out by Sir Robert McAlpine and Sons, and not by Sir William Arrol and Co., Ltd., as inadvertently stated in this column last week.

THE Railway Returns for 1934 show that at the end of that year British railways had 20,233 miles of running line, of which 7688 miles were single tracked. They had 12,445 tender engines and 8098 tank engines; the total empty weight of these was 991,349 tons, or an average of 48·29 tons. There were 41,200 carriages for steam-worked trains, with a total seating capacity of 2,321,293, and 3078 electric motor or other vehicles for electrical operation with a total of 225,290 seats. The number of railway-owned wagons was 622,872, with a total capacity of 7,224,910 tons, and an average of 11,599 tons per wagon.

THE Manchester Ship Canal Company is seeking in the present session for powers to construct over 3 miles of new railway, and, incidentally, definitely to close a derelict canal. The latter was known as the Manchester and Salford Junction Canal, which made an important connection between the river Irwell and the Rochdale and Bridgewater Canal systems at the point, near Manchester Central Railway Station, where those two canals join. The canal was opened on October 28th, 1839, but its course was obstructed during the time the Cheshire Lines Committee's railway was being built in 1872, and in course of time since the canal has been covered over.

IT is officially announced that Mr. A. E. Tattersall, in anticipation of the forthcoming retirement of Mr. F. Downes, the signal and telegraph engineer, southern area, L.N.E.R., has been appointed to succeed that gentleman. Mr. Tattersall joined the signal department of the Lancashire and Yorkshire Railway, under Mr. Rayner Wilson, some thirty-eight years ago, and subsequently went to the Great Southern and Western of Ireland, the Metropolitan, and then the Great Northern. Soon after the absorption of the latter railway in the L.N.E.R. system he went to York as signal and telegraph engineer of the North-Eastern Railway, which position he now vacates on his removal to London.

MR. G. F. THURSTON, the divisional general manager of the southern area of the London and North-Eastern Railway, and an old officer of the former Great Eastern Railway retires at the end of the present year. He is to be succeeded by Mr. C. H. Newton, who has been the chief accountant for the whole of the L.N.E.R. system since 1928. Mr. Newton started in the accountants' department of the Great Western Railway in 1897, and joined the Great Eastern in 1916, where he rose to the position of chief accountant. When a rearrangement of the various officers was necessary as a consequence of grouping at the end of 1922, Mr. Newton became assistant accountant, L.N.E.R., and then succeeded to the position he now vacates on the death of Mr. C. L. Edwards in 1928.

THE Ministry of Transport, working in conjunction with the Surrey County Council, is responsible for a scheme of the Automatic Electric Company for controlling street light signals by invisible rays. It is to be installed on a pedestrian crossing between Netley-gardens and Dore-gardens, on St. Helier-avenue. This highway is regarded as an ideal site for the experiment now being undertaken. There are dual carriageways, cycle tracks, and a central verge. Pedestrians will be required to cross in two stages and time will be allowed for them to rest on the refuge, which divides the road, before completing their journey. The rays will detect the approach of road vehicles and cyclists, and fast-moving vehicles will give a longer notice of their approach than will slow-moving vehicles and cyclists.

THE Southern Railway between Woking and Basingstoke, on which occurred the slip near Winchfield on November 17th, happily possessed four running lines. These, reading from south to north, were the down slow, down through, up through, and up slow. The slip not only obstructed the down slow line, but forced the down through out of alignment. That left only the two up lines free, but the advantage of having four running lines was that a connection could be put in between the existing down through and the up through line on each side of the slip and so converted the up through temporarily into a down line, whilst the up slow became the only up line. There was thus an ordinary double line, without any of the delays due to single-line operation for the obstructed area. An interesting feature in train working was that the West of England trains travelled through Staines to Reading and there joined the Great Western and ran over the Berks. and Hants branch to the Southern station at Basingstoke. The difficulties were greatly relieved by the fact that the accident occurred early on a Sunday morning when there were fewer trains to be dealt with.

ON Saturday and Sunday last, December 7th and 8th, the centenary of the German railways was celebrated at Nuremberg. The British delegation, which was welcomed by Herr Hitler, included Sir Josiah Stamp, Brigadier-General Sir Osborne Mance, and Mr. R. Holland-Martin. Sir Josiah Stamp placed a wreath on the memorial to railway workers, among the names on which is that of William Wilson who drove the first German railway engine. The ceremony was followed by a parade depicting railway equipment as it has evolved during the last hundred years. The first railway line in Germany was opened on December 7th, 1835, between Nuremberg and Furth. Two years later the Leipzig–Dresden line was opened, and in 1838 the Berlin–Potsdam connection was made. At the time, the German railways were constructed by private companies, and they imported much of the material from England. The wars of 1870 and of 1886 caused Bismarck to nationalise the Prussian and Hessian systems, which comprised about three-fourths of the whole at the time. In 1920 the whole system was taken over by the Reich, and in 1924, as recommended by the Dawes Plan, a company was created to manage it, the Deutsche Reichsbahn Gesellschaft. In the last report of the Reichsbahn, issued in 1934, the balance sheet total was £2,345,558,000, a figure which gives some conception of the size of the organisation.

Miscellanea.

A NEW technical college, built at a cost of £180,000, has been opened at Coventry.

IT is expected that it will be possible to enter the area affected by the explosion at Gresford Colliery within the next few weeks.

ONE of the Soviet synthetic rubber factories is constructing an experimental plant for the production of ethyl acetate from the factory's waste products.

THE Coal Utilisation Council has arranged for the testing of bunker coals at the Fuel Research Station at Greenwich, and for this purpose a Scotch marine boiler has been installed.

SPEAKING at Manchester, the Minister of Transport said that in the first forty-eight weeks of this year there had been 10,000 fewer road casualties than in the corresponding period last year.

ACCORDING to the Sheffield Chamber of Commerce the production of steel in Sheffield is 100 per cent. greater than four years ago, and the output of finished products has been more than doubled.

A NEW pipe line for oil, some 440 miles long, has been put into operation in Russia. It connects the oilfields at Emba to Orsk and is expected to be capable of transporting half-a-million tons of oil a year.

THE conversion of the Glasgow subway from cable haulage to electric traction has now been completed. The subway provides a circular route round the city and the conversion has cost some £110,000.

DR. J. D. POLLOCK and Mr. P. D. Liversidge have been appointed President and Vice-President respectively of the twelfth International Acetylene Congress which is to be held in Caxton Hall, Westminster, next June.

WHAT is believed to be the largest lifting magnet ever made in this country was recently despatched from the works of the Igranic Electric Company. It measured 65in. in diameter and weighed some 4 tons 5 cwt., and will lift over six times its own weight.

WHAT is claimed to be the largest and fastest paper-making machine in the world has been completed and installed at Sittingbourne, Kent. The machine, which weighs some 2000 tons and is nearly 500ft. long, is capable of producing 2500 miles of paper, 30in. wide, a week

THE Department of Overseas Trade announces that there are now two posts of Deputy Comptroller-General in the Department. One of these has been held by Mr. E. R. Eddison since April 1st, 1930. To the second post the Secretary of State for Foreign Affairs and the President of the Board of Trade have appointed Mr. Arthur Mullins, formerly a Director of the Department and Commissioner of the Overseas Trade Development Council.

THE work of laying the new submarine Australia-Tasmania cable across Bass Strait has been completed. It connects the land lines of the Australian mainland with those of Tasmania, thus completing the establishment of telephonic communication between all the states of the Commonwealth. This cable, 161 nautical miles in length, will provide for the simultaneous operation of at least five telephone circuits, a broadcast programme, and seven high-speed telegraph channels over a single insulated conductor.

OWING to a shortage of coal the Edinburgh Corporation has had to take electricity supplies from the Highland and Galloway hydro-electric schemes. This statement was recently made by the manager of the Edinburgh Electricity Department, who added that his department is having difficulty in getting sufficient quantities of coal to keep up its supplies of 95 per cent. of the city's industrial electric power. The cause of the shortage is said to be due to the "manipulation, raising of prices, and holding up of supplies" by the dealers, and the Government has been asked to take action.

THE recent memorandum of the Utilisation of Coal Committee, entitled "The Drying of Washed Coal," points out that with steam coals used in boiler furnaces the fuel consumed in evaporating 6 per cent. of moisture would be 17 lb. per ton of coal of calorific value 12,500 B.Th.U. per lb.—assuming a boiler efficiency of 70 per cent.—costing, at 13s. 4d. per ton, 1·2d. By reducing the moisture content of the coal charged to the boilers from 12 to 6 per cent., the calorific value would be increased from 12,500 to 13,400 B.Th.U. per lb. By drying the coal to 6 per cent. moisture, therefore, a more valuable steam-raising fuel would be provided.

THE formation of a library of books dealing with every aspect of illumination, photometry, and kindred subjects is now being undertaken by the Illuminating Engineering Society. Certain books on these subjects are available at the chief scientific and technical libraries, but there is at present no place where all such literature is assembled together for ready reference. Arrangements for housing the collection are not yet complete, but a Library Fund has already been started and offers of contributions of books are being received. The Society's Hon. Secretary (Mr. J. S. Dow, 32, Victoria-street, S.W.1) would be grateful to hear from any members or others who would be willing to contribute appropriate books of scientific or historical interest.

A NOTE in the *Engineering News-Record* says that muddy water is being discharged from the mouth of the diversion tunnel below Boulder Dam instead of the crystal-clear stream that has been flowing from the tunnel for several months past. The lake now is about 310ft. deep at the dam and is 80 miles long. Two explanations are given of the new development. One is that the silt-laden waters entering the lake far above the dam are heavier than the clear lake water and so move along the bottom to the dam without entirely losing their load of silt. The other is that silt has been deposited in the upper reaches of the lake until it has reached an unstable level, and that it now again is being eroded by the movement of the water along the bottom and so is carried along the bottom to the dam.

Air and Water.

THE Government has decided to ask Parliament to sanction a further £2,000,000 as subsidy to the tramp shipping industry for 1936.

IT is reported that a number of extensions are being made to the Zeppelin works at Fredrichshafen to expedite work on the new dirigibles "L Z 129" and "130."

THE Clyde Navigation Trustees have recommended that a new vehicular ferry boat, costing £37,000, should be built to replace the one at Whiteinch, which is inadequate to cope with the increased traffic.

FROM January 1st to November 20th, 5315 vessels passed through the Suez Canal, paying dues of 789,160,000 francs. For the corresponding period last year the figures were 5024 vessels and 759,210,000 francs.

OUT of the twelve new civil flying schools being constructed for the initial training of *personnel* for the Royal Air Force, eight have already been opened, and the remainder are due to be completed by February next.

A MILES "Hawcon" monoplane with a 200 h.p. "Gipsy Six" engine has been specially built for the Air Ministry to carry out high-speed research on thick wing sections. With it wings of different thickness chord ratios will be tested.

IN the five years between July, 1930, and July, 1935, the number of insured workers in the shipbuilding and repairing industry fell from 204,720 to 157,230, a decrease of 23·2 per cent. In the marine engineering industry the decrease was from 60,070 to 45,650, or 24 per cent.

THE French seaplane "Lieutenant de Vaisseau Paris" is reported to have left Bordeaux to fly to Martinique by way of Dakar, West Africa, and Natal, Brazil. According to the Paris correspondent of the *Daily Telegraph*, the machine may attempt to break the world's seaplane record by flying from Dakar to Martinique.

ANOTHER all-welded vessel has been ordered from Swan, Hunter and Wigham Richardson, Ltd., by the Quebec and Ontario Transportation Company, Ltd. The vessel will be of 2087 tons gross, and will be the largest all-welded vessel yet built. It will be remembered that a similar all-welded vessel, the "Joseph Medill," was never heard of again after sailing for Canada in August last.

IN the course of a recent lecture given in Glasgow, Dr. James W. French, director of Barr and Stroud, Ltd., pointed out that while by the Spooner Act it was decreed that the Panama Canal should be of sufficient size to take the largest vessel that might reasonably be anticipated in the near future, those expectations have already been exceeded, as the "Queen Mary" is longer than the present locks.

A NOTE in the *Far Eastern Review* says that sites for six aerodromes have been selected and approved in Borneo for the projected air route between Singapore, Borneo, the Philippines, and Hong Kong. The aerodromes will be at Kuching, Borneo, Bintulu, and Miri, in Sarawak, and Jesselton and Kudat, in British North Borneo. They may serve as a final link in the Pacific air service planned by America, *vid* Honolulu, Wake Island, Tokyo, and Shanghai.

IT is expected that a contract will shortly be placed by the Admiralty for the construction of a non-magnetic ship. The vessel, which will be named "Research," will be constructed mainly of wood bolted together with bronze bolts. All rigging will be of hemp and the oil engines so built that practically all iron will be eliminated. The object of this ship is to investigate the problems of the variation of the earth's magnetic field. The last non-magnetic vessel was the "Carnegie," which was destroyed by an explosion in Apia Harbour in 1929.

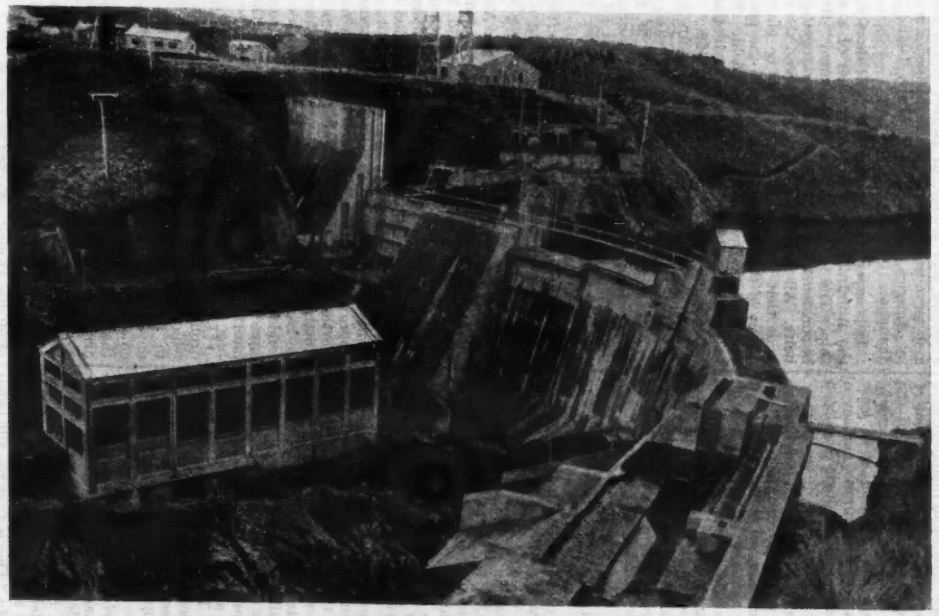
AN official announcement made at the close of the Transatlantic Air Mail Conference at Ottawa on December 2nd, states that after consideration of the problems involved arrangements have been unanimously agreed upon which, subject to the approval of all the Governments concerned, should enable survey flights to be undertaken next year and an experimental Transatlantic air mail service to be established soon afterwards. This will be followed by a mail and passenger service on a minimum schedule of two flights a week each way.

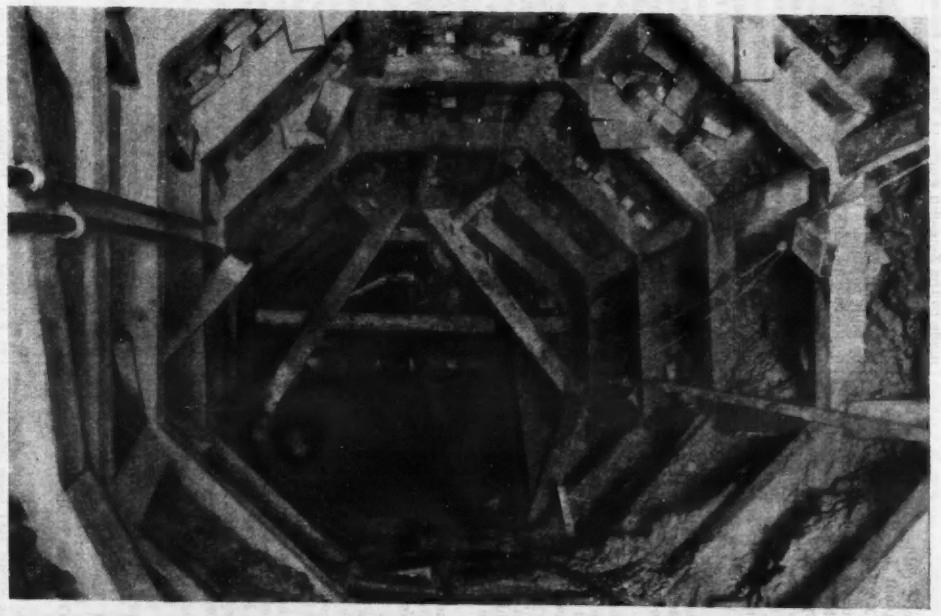
A NOTE in *O'Connell's Coal and Iron News* says that nearly a million pounds has been expended on improvements and developments to the Grand Union Canal. Parts of the waterway extending some 250 miles between London and the Midlands have been widened to accommodate larger and mechanically propelled barges, while locks have been constructed, bridges built, and embankments strengthened. In addition to this waterway, other improvements have been carried out in recent years in Northern England, particularly between Newark and Nottingham, and thousands of pounds have been spent on barges and equipment. As an instance of improving tendencies in recent years, the railway losses on canals have been halved in the past five years, the total deficit for 1934 having dropped to £33,965.

IT has been authoritatively announced that the Aerodromes Advisory Board has ceased to exist. This Board, which was a purely voluntary organisation, was set up in 1933 by the principal institutions concerned in the development of the groundwork of aviation, with the co-operation of the Air Ministry. A note in *Flight* says that the Air Ministry explains that the time has now arrived for the State itself to deal with aspects of civil aviation which, in their earlier stages, had necessarily to be left to the good will of voluntary bodies. It has, in fact, been found necessary to institute machinery through which the Air Ministry can obtain the combined advice of all departments affected by civil aviation developments. For this purpose two strong inter-departmental official committees have been set up, one to advise on the best means of developing civil aviation inside Great Britain (under Sir Henry Maybury), and the other concerned with routes external to this country (under Sir Warren Fisher). Much of the work formerly performed by the Aerodromes Advisory Board will therefore be dealt with by these committees.

HYDRO-ELECTRIC POWER SUPPLY OF DUNEDIN, NEW ZEALAND

(For description see page 620.)





ABOVE:—LAKE MAHINERANGI DAM AND POWER-HOUSE
BELOW:—LOWER OUTLET OF NEW TUNNEL

ABOVE:—VIEW IN TUNNEL UNDER CONSTRUCTION
BELOW:—PIPE LINE TO BE REPLACED BY TUNNEL

The Engineer

DECEMBER 13, 1935.

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THE HUMAN MACHINE.

AT the Conversazione of the Royal Society held in May 1934 there were shown two exhibits which, interesting individually, were doubly interesting because they illustrated the application of certain experimental equipment to two apparently disconnected investigations. One of these exhibits, shown by Professor A. V. Hill, was concerned with "the time relations of the excitory process in nerve during continued stimulation" or, in words sufficiently exact for our present purpose, with the electric response from a nerve when stimulated. The second exhibit was shown by Professor E. G. Coker and demonstrated that it was possible to determine quantitatively the stress distribution in a rigid body from the very minute temperature changes accompanying the application of load to it. The critical portions of the experimental equipment were identical in the two exhibits. For the purpose of his investigation Professor Hill had evolved improved thermopiles and thermocouples and an improved galvanometer, all of which had to work with extremely great sensitivity and accuracy. For his investigation of thermo-elastic phenomena Professor Coker employed duplicates of Professor Hill's thermopiles and galvanometers. Taken together the two exhibits illustrated the fact that modern physiologists, with the aid of the refined equipment now at their disposal, can probe the mysteries of living matter in much the same way and to much the same extent as engineers and physicists can pry into the secrets of inert matter. A fortnight ago in his Thomas Hawksley Lecture before the Institution of Mechanical Engineers—of which a summary was printed in last week's issue—Professor Hill presented an authoritative and highly instructive account of the general conclusions which physiologists have so far reached concerning the mechanism of the processes by which living matter, and especially the human body, performs its functions. He revealed a general similarity between physiologists and engineers in their outlooks upon the problems which they study and a considerable measure of similarity in the investigational methods and equipment which they employ. He showed, too, that living matter in some of its activities resembles surprisingly closely the machines and engines which the engineer builds out of inert matter. Equally, however, he showed us that there are differences which stamp our machines and engines as being of human origin and design.

In our more pessimistic moods we sometimes brood upon the fact that our engines will not convert into useful work more than about 20 to 30 per cent. of the thermal energy supplied to them. We may now take comfort from the fact revealed by Professor Hill that the human body as a work-performing machine has an efficiency, measured on the same basis, of not more than 25 per cent. at the best of times and frequently less. The similarity of this figure with that for the efficiency of an engineer's prime mover is striking. Even more striking is the fact that the human and mechanic efficiencies vary with the speed of working in a similar manner. In both cases there is one speed of working, other conditions being constant, which gives a maximum efficiency; at speeds above or below this value the efficiency, human or mechanic, falls off. Equally, too, does the human machine reproduce the ability to deal with an overload which its mechanical counterpart possesses. Working at a steady rate a vigorous man can liberate energy at the rate of about 0·38 h.p. His system, however, contains an accumulator element and by calling upon it he may greatly increase his output of power. For a few seconds it may be as high as 1·6 h.p. but he will require a considerable period for recovery afterwards in order to build up once more the reserve in his accumulator element. In passing we may note that in this high momentary output attainable by man we have one more demonstration of the fact that Watt's "horse-power" errs, as it was intended to err, on the side of modesty. In these respects, efficiency and variability of output, the human and the mechanic machines are, it will be seen, closely comparable. But lest we take undue pride in the comparison let us note some vital points of difference. The comparison, it may be said at once, is unfair to the human machine. It is not merely the power plant of a ship or the locomotive of a railway but the whole ship or the whole railway from the captain's bridge to the propellers or from the general manager's office to the permanent way. It includes the equivalent of the man on the bridge and the man in the engine-room, and a system of telegraphic communication between them more complex than the most complicated automatic telephone exchange. In estimating the efficiency of the human machine is it fair to neglect, as part of its useful output, the thought which controls its motion and activity or the working of the mechanism which by some mysterious, as yet unknown, process converts thought into terms of a physico-chemical process? The comparison is unfair in another respect. The human machine possesses an almost miraculous ability for effecting self-repair. When our locomotives carry their own running sheds about with them, when our ships carry their own dry docks, it will be time enough to begin to take pride in the similarity of the efficiencies of the human and the mechanical prime mover. In an entirely different connection the comparison is seen to be still more unfair. The human machine is not, mechanically regarded, simply a power-producing engine; at the command of the brain it can, without the least outward change, convert itself into the equivalent of a machine, such as a hydraulic press, which exerts force as distinct from doing work. Muscle fibre, as Professor Hill will be found to explain, may, while exerting tension, diminish its length thereby doing external work in the strict Newtonian sense. It may also at the command of the brain exert tension without changing its length, thereby establishing a force without doing external work. This dual function is not normally encountered in machines of man's devising. A strange feature of the human machine, a feature which alone would distinguish it from a mechanical counterpart, is the fact that even when it is exerting force without doing external work it consumes energy. Still stranger, it consumes energy when external work is done upon it, as for example when we walk down a flight of stairs.

The human body is clearly, up to a certain point, wonderfully similar to a heat engine but beyond that point the resemblance ceases and we are presented with features which, if we encountered them in practical engineering, would upset both our practice and our philosophy. Doubtlessly the behaviour of the human machine when it differs radically from the behaviour of an engineer's machine can, in many cases, be explained in terms which do no violence to physical theory. Doubtlessly, too, any inability to explain certain aspects of its behaviour in such terms arises, or must be presumed to arise, from insufficiency of our knowledge and not from any fundamental departure of its behaviour from obedience to physical law. Yet in one prime respect our bodies, regarded as heat engines, appear to present a puzzle. No heat engine, as we know from the science of thermodynamics, can work if it is not in communication with a high temperature source of heat and a low temperature sink. In what part of the human body does the low temperature sink reside and how is it maintained, from birth until death, at its low temperature? Probably it is quite wrong physiologically to take 98·4 deg. Fah. as the temperature of the hot source. But if we take it at that we must, apparently—in order to account for an efficiency of 25 per cent.—look for some sink of heat at 74 deg. or less. Does it lie in the skin and the cooling effect of the evaporation taking place through the pores? If it does how do we develop the energy required to lift ourselves out of a hot bath or how do we manage to move at all in the tropics or on a hot summer's day in the sun? Is it possible that the body operates because it has the power of running one part of itself as a boiler house and another part as an ice-cream factory? We, and we think many other engineers, would like Professor Hill to answer these questions, as answer them he no doubt can.

Railway Directors and Electrification.

A FEW weeks ago Sir Josiah Stamp told the British Railway Stockholders' Union that "in Parliament and in the Press there were persons who, with an air of sweet reasonableness, would like to interfere with the companies' discretion on the question of motive power. They talked of electricity and Diesel engines, they always knew the best for railways, but in nearly every case there was a personal interest in the discussion." It is not impossible that Sir Josiah was speaking with a threepenny pamphlet which had then just been issued by the Electrical Development Association peeping out of his pocket. That pamphlet is entitled "The Case for Electrification of Railways," and were it not plain propaganda addressed to a non-technical public which it wishes to make ever more and more electrically minded, we should have to charge it with the venerated recreation of attempting to instruct an old lady in an art which one might have supposed, despite the ancient quip, would not have appealed to her. With the "Case" made in the pamphlet we have little or no quarrel; the arguments are presented clearly and effectively, and the interpretation put upon facts is quite legitimate from the propagandist's point of view. What we ourselves regard with disfavour and what may have been rankling in Sir Josiah's mind is the rather patronising manner in which the present advisers of our great railways are treated. There is no justification whatever for assuming that the railway companies do not know their own business best. It is perfectly legitimate for the propagandist to put forward arguments in the hope of inducing them to alter their opinions, but it is not fair to charge them with rank folly—for that is what it comes to—if the arguments fail to convince them. Electrification of the main lines of the three major companies in this country has not been adopted because the arguments for it are not as strong as those against it. There is no other reason.

The pamphlet asks why the railway companies, apart from the Southern, "appear to be reluctant to embark upon conversion." The explanation, it goes on to say, is "quite simple." "Great Britain was the pioneer of the steam railway; directors, engineers, and traffic managers alike have been reared in the steam tradition, and feel an immense and legitimate pride in the development of the steam locomotive, and in the public service which has been founded upon it. To men who live, move, and have their being in steam, the advent of electric traction is bound to be unwelcome, even though it promises to bring a financial benefit." The pamphleteer who wrote these words can hardly be acquainted with the railway administrations of the present day. In the past, in the days of Webb, let us say, the Locomotive Superintendent was a king in his way. His opinion on technical, and even traffic, questions was paramount. He directed the directors and almost ruled the line. All that has been altered. The Chief Mechanical Engineer has replaced the Locomotive

Superintendent, and his duties have been reduced to the supply and maintenance of engines and mechanical equipment. Moreover, every one of the railways has an Electrical Engineer, who may safely be expected to keep electrical aspects before the directors. Furthermore, every one of the railways has been made familiar with electrification by its extension for suburban services. There is neither amongst the directors, nor the management, nor the engineers any ignorance about electric traction or any rooted bias against it. It has been, and is being constantly examined, and were it now worth while on main lines it would be adopted with no more hesitation than is naturally called for when a vast revolution has to be made. May we ask in what way the "traditions" of the Southern Railway differ from those of the other companies? Was not it also reared on steam; had it not also Locomotive Superintendents as famous and as powerful as those of other lines? Have not many of its locomotives come down in history? Are its directors and managers men of a different kind from those of other railway companies? Yet it has not refused to adopt electrification. It has seen that for its particular service the electrical operation of trains is economical and technically satisfactory. But it would be the first to acknowledge that its conditions differ from those of the other three companies, and that what is suitable and proper for it is not necessarily suitable and proper for them.

By this defence of the railway managements and directorates, we shall, of course, lay ourselves open to the charge of being as much under the influence of the steam tradition as they. That will do us no harm, for our readers are well aware that to all methods of railway traction we give equal attention in our pages. Not being propagandist for any one method, we can be fair to them all. We admit the advantages which electrification offers, but we see also the very grave and serious disadvantage, concerning which this pamphlet is silent, that the independence of an external source of power which the steam locomotive and the oil-engined locomotive enjoy is wanting. The importance of that independence will be denied by electricians, but it remains manifest to everyone else. Hence even if the choice lay between the steam engine and one of the alternatives, we should lean towards the internal combustion engine rather than to electricity. Moreover, if we had to rely on the words of rival propagandists we should find it difficult to decide between those who favour electricity and those who favour oil. On economics both make effective cases. A further reason for opposing general main-line electrification is that, as a consequence of the vast expenditure involved, research into other methods of propulsion would be arrested, and the possibilities of the oil locomotive would be killed for a century. That would be undesirable in the highest degree. The oil-engine locomotive, with its high thermal efficiency and an independence equal to that of the steam locomotive, presents a far better solution of the railway problem than general electrification. Despite the difficulties which it has encountered, we still believe that it may achieve success and in the meantime the development of high-speed railway coaches—in contradistinction to locomotives and trains—offers a means of meeting the desire for high-speed passenger transportation. As long as we have independent systems, like steam or oil traction, experimentation and research can go forward; but general main line electrification would put an end, once and for all, to the examination of other forms of mechanical transport on our railways. That would be tolerable were no alternatives in sight. But with the steam locomotive daily improving its performance and with oil locomotion still in its infancy, and with both possessing the invaluable quality of total independence, it would be, we submit, quite intolerable.

Literature.

Offensive Trades. By DAVID RONALD, M. Inst. C.E., F.R.S.E. With Foreword by the late Sir LESLIE MACKENZIE. William Hodge and Co., London and Glasgow. 1935. Price 15s.

OFFENSIVE trades are defined in the introduction of this handbook as of two classes, namely (1) those enumerated as such trades in the various Public Health Acts, and (2) those declared to be offensive or noxious by the orders made by local authorities under the powers conferred by these Acts. Mr. David Ronald, the author, is the Chief Engineer of the Department of Health of Scotland, and he has written chiefly for medical officers of health, sanitary inspectors, and officials of local authorities who may be concerned in the administration of the laws relating to offensive trades. The needs of students who are preparing to undertake such duties, and also of the manufacturers who are now carrying on or contemplate establishing businesses of this kind, have also been kept in mind by the author, and both these classes of readers will find much information of interest and value in Mr. Ronald's work.

The author claims for the contents of his handbook that they are based not only on long personal experience in the Department of Public Health with which he is connected, but also on the results of his own research work, and upon subsequent large-scale experiments carried out with the help of many individuals and firms over a period of several years. Sir Leslie Mackenzie, until his death recently, was the Medical Member of the Local Government Board for Scotland, and of the Scottish Board of Health, and in a foreword to this book he states that nowhere has he come across any English book which discusses more clearly the particular group of problems connected with the carrying on of these offensive trades, and he draws particular attention to the chapter which discusses the use of chlorine for the purification of noxious gases and vapours. For this particular investigation the author has had the assistance of Imperial Chemical Industries, Ltd., and of other firms which have helped in the running of a small-scale plant.

In an introductory chapter the author states that a report prepared by Dr. Edward Ballard, one of the Board's medical officers in the years 1875–77, which was first published in 1882, has hitherto been the chief source of facts and information for the offensive trades industry, and that since the appearance of this printed report no book bearing directly upon offensive trades has been published. At the date of Dr. Ballard's report the heating or boiling of the raw materials in the various processes was carried out in coal-fired boilers, although even at that date the more advanced manufacturers were employing steam. In the majority of cases the coal-fired boilers appear to have been covered, and the vapours evolved in the process of boiling were led to the stokehole and were passed through the boiler fire. In a few instances, however, especially in the larger works, the vapours were cooled, and were washed in condensers, but these were of very primitive construction when compared with those in use to-day. The use of steam for boiling was the first step forwards in the evolution of the industry, while the second step was the introduction of jacketed digesters, from which the modern concentrator plant has been evolved. In the larger works the vapours from these concentrators are now cooled, and are then scrubbed in elaborate condensing plant, whilst the residual air and gases from the latter are either burned or deodorised. The war led to a further advance in the industry, for a demand grew up for fish-meal and meat-meal for poultry and pig feeding, and later on for cattle feeding, and it is worthy of note that at the date of Dr. Ballard's report fish-meal was unknown, whereas to-day the largest "offensive" works are those in which fish and fish offal are employed as raw materials. The demand for meat-meal also has led to the installation at some of the larger works in which horse and cow flesh are used, of up-to-date plant on the same lines as that employed for the manufacture of fish-meal, and in most of the large public abattoirs plant has been installed for the recovery of grease from condemned carcases and from offal, and for reducing these materials to a meat-meal.

This description of the various types of raw material dealt with indicates that in almost every large town "offensive trades" of one kind or another have been established. The processes involved in the concentration of waste meat and fish and the drying of blood, &c., in tallow melting, fat melting, and degreasing of bones, are the cooking of the materials and the removal of the moisture, and these operations are now almost everywhere performed in steam-jacketed vessels known as concentrators. On the completion of the cooking process, which occupies from three to ten hours, the concentrator is emptied and a fresh charge of raw material is provided, while the water vapour, which has been driven off by the heat during the cooking process is drawn by fans through a condensing plant supplied with a large amount of wash water. This water, containing the soluble portion of the gases, is run to waste, either into a public sewer or to the sea, but if into a river, some previous treatment is necessary. The unabsorbed gases and air are, however, very foul, and until recent years this foul air gave rise to considerable trouble, for even when passed through special furnaces the result was only partially successful, and the usual method of sending these gases through the furnace of the steam generating plant had been found to be almost useless. Chapter 8 of the book, which deals with the deodorisation of condenser air, is, therefore, one of the most valuable, since it contains a record of the author's own laboratory investigations, and details of the results which are now being obtained with the use of liquid chlorine for the deodorisation of these foul gases. He sums up the results by stating that the plant for gaseous chlorination is cheap to install and to operate, for the labour costs are practically nil, and liquid chlorine can now be purchased at a very low price.

The book certainly attains the objects set out by the author and by the late Sir Leslie Mackenzie in the preface and foreword, and if the author's claim is correct that no English book has appeared on the subject since the publication of Dr. Ballard's "Survey of Offensive Trades" in 1882, it meets a real need. It is well printed and illustrated, and is provided with a useful index.

A Study by Means of Photography of the Interruption of Medium-power Electrical Circuits. By JAMES ANDERSON. Birmingham: Allday, Ltd., 128–130, Edmund-street. 1935. Price £5 5s.

DESCRIBED by the author as just a plain tale from the test-room, this book of 140 pages, corresponding in size to those of THE ENGINEER, deals with some of many thousands of tests carried out by Mr. Anderson and his assistants at the works of George Ellison, Ltd. As the title implies, the tests, which were begun as far back as 1914, were made on medium-power circuits, and were of a simple nature involving the use of nothing in the way of measuring equipment beyond a camera, a voltmeter, an ammeter, and a foot rule. The field covered differs widely from that which has mainly claimed attention, namely, the interruption of high-power A.C. circuits requiring plant and apparatus far beyond the financial resources of the average switchgear manufacturer. There is nowhere, the author contends, in the whole of electrical literature where one can turn for exact information regarding contact separations and the clearances required for medium-power circuit interruptions. Particulars of tests covering very limited fields have been published, but no one seems to have made an attempt to collect results and present them in useful form.

But in this book there are to be found no fewer than 3000 photographs of arcs corresponding to between 20 and 11,000 ampères at about 400 volts A.C. and D.C., together with many charts and much comprehensive information concerning arc formation and suppression in air, oil, and water. The tests cover slow and quick breaking with inductive and non-inductive loads, and considerable attention is paid to the effects of A.C. and D.C. magnetic blow-outs under different conditions. Many interesting facts concerning medium circuit interruption are brought to light, and although in many cases the author seems to find difficulty in drawing definite conclusions from his investigations, the information given provides much food for thought. To the practical man in particular the volume should specially appeal. As Mr. Anderson says, in dealing with the suppression of arcs by means of condensers, an ounce of practice is worth pounds of theory, because there are so many indeterminates and variables liable to make formulæ more or less useless. Highbrow and hypercritical workers are recommended by the author to give the book "a miss," for they will find nothing in it that meets their tastes.

Although, apart from traction work, A.C. has long been replacing D.C., many D.C. tests are described, particularly on inductive circuits, which are, of course, associated with many branches of electrical work. The breaking of the field circuits of alternators is one of the problems discussed. Much information is given on tests on A.C. and D.C. magnetic blow-outs, but here, again, there are questions concerning their action which the author is still unprepared to answer. While it is easy enough to form theories and assume that they are correct, it is often more difficult to support them by the results of practical tests. Mr. Anderson is clearly a firm believer in getting to the root of things, and in utilising the camera to that end. To discover whether accepted theories are correct or to find solutions to problems that have never been solved has been his aim, but the whole subject is said to be still "wropt in mystery."

The main difference between Mr. Anderson's investigations and others on medium-power circuit breaking is that in the former case the evidence of the camera has been placed before everything else. It may be said, in fact, that the book tells the story in pictures rather than in words, although it must not be imagined that essential explanations are missing. In places the text is quite interesting as, for example, in the section dealing with the question of breaking the circuit at the zero point of the current wave where the tantalising experience is mentioned of seeing a circuit broken nineteen times out of twenty-four without producing a perceptible arc. If this could be done 100 per cent.

of the times the circuit is interrupted, there would, of course, be no breaking problem. A patented synchronous motor-operated mechanism mentioned in this connection is said to open single-phase circuits of 1 to 0·18 power factor without a spark and without readjustment. Tests are described elsewhere in the volume on the breaking of circuits in small enclosures at pressures as high as 3500 lb. per square inch, and it is shown that, subject to certain conditions, the pressure principle is good. No attempt has been made, however, to cover investigations on such things as steam, air, and oil blasts, or breaking circuits in inert gas or vacuum. The volume is already large and expensive, and could scarcely stand extension.

That medium-power circuit breaking has reached the state of finality the author clearly does not believe. There must be better ways, he says, of stopping the current flow than by violently rupturing the circuit. Grid-controlled valves or similar arrangements are apparently what he has in mind, but for the time being, at any rate, tests such as those covered by this book cannot be ignored, notwithstanding that in many cases they do not appear to have led to very definite conclusions. From 14,000 A.C. circuit-breaking tests in oil and water precious little light has been thrown on ratios for volts, ampères, and speed. The total energy in the arc appears to be much the same at high and low breaking speeds, whilst there is no particular difference in the dimensions for 380, 230, or even 110 volts, the arcs being in reality a series of explosions.

Switchgear designers, students, and even switchgear users should find the book both instructive and useful. Based as it is on simple experimental work carried out with the aid of simple equipment, it makes a special appeal to practical men with a dislike for highbrow theory. Many who would gladly have the volume will probably be deprived of doing so by the price, but we note from the publisher's announcement that reductions are made to teaching institutions, students and those holding staff positions.

Psychology in Business and Industry. By JOHN G. JENKINS. London: Chapman and Hall, Ltd. 1935. Price 12s. 6d.

NOWADAYS there are few people who do not dabble a little in psychology. A seductive air of mystery and the occult still hangs about it, despite the efforts of modern practitioners to make it as material and commonplace as a two-foot rule. In fact, it now means ever so much more than the study of the spirit, having been extended to include man's unconscious muscular reactions to fatigue, monotony, colour, light, air conditions, food, environment, and other material factors. For hundreds of years the works manager knew about these things, but he never thought of elevating his knowledge to a science, and he would have gaped, if his reactions had not been of a more personal and forcible character, had any one called him a psychologist.

In this book the Assistant Professor of Psychology at Cornell converses pleasantly about Psychotechnology. His book is intended for students, but it is not a forbidding textbook. Actually, it seems to us, Professor Jenkins is too open-minded to write a dogmatic work. At any rate, we have observed that in many cases he rejects statistics as inconclusive. To take one case, that of "Narcotics." With some personal pleasure we have noticed that he refuses to side with those who condemn tobacco, and if he is not on the side of strong drink he is not, speaking scientifically, a prohibitionist. We like, also, his remark on efficiency. "It would," he writes, "not be surprising to discover that efficiency, like so many other popular concepts, should not be indiscriminately adopted as the end and aim of all efforts at industrial improvement." It would be unfair to rob the reader of the pleasure of finding out for himself how the author leads up to that conclusion.

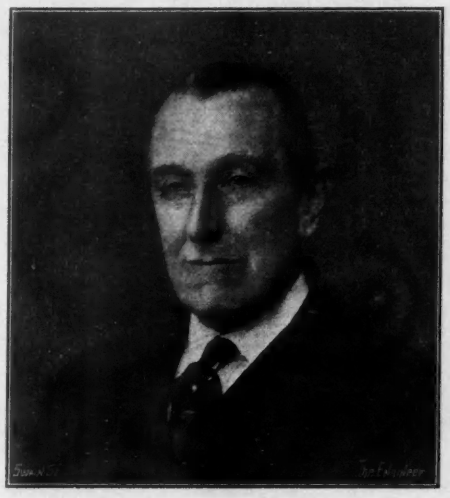
A chapter which will appeal to all who receive voucher copies of THE ENGINEER is entitled "Psychological Contribution to Advertising," which is followed by one on "Securing the Attention of the Reader," and another on "General Psychological Problems in Selling." In these three chapters the cautious nature of the author is apparent; in all he rather suggests lines of thought than attempts to lay down rules. Advertising he regards as an excellent subject for psychotechnological study, but remarks that, "Although it cannot be denied that the psychological investigator has made contributions which have influenced the art of writing advertisements, study of actual advertising practice will convince the reader that this influence has not approached the amount indicated by the nature of the field itself." We find ourselves wondering if any laws that the psychologist could devise would be better than the experience gained by advertisers themselves. May it not be said that every individual advertisement is an experiment in itself, and one that can be repeated if it is successful? The advertising of trade products is invariably carried out by series of insertions, which may change irregularly or may be varied in prearranged rotation. In any case, the advertiser has the means of judging the results and can modify his methods by his experience. In this, as in other matters investigated by the psychologist, the question of "controls" is one of the first importance. To take an example, it would certainly be fallacious to use advertisements in *Punch*, let us say, as controls for advertisements in THE ENGINEER. The interests of the average readers, and above all what readers expect to find, must be taken into account.

We recommend the book as a useful introduction for those who desire to know how far psychology is making headway in industry, and as an elementary guide to the principles employed by the psychotechnologist.

Obituary.

SIR JOHN FIELD BEALE.

WE have to record with regret the death on December 9th of Sir John Field Beale from pneumonia at the relatively early age of sixty-one years. Sir John might be described as a member of the class of "professional chairmen," for which he was particularly suited by his personality, his abilities, and his training. He was a director of no less than twenty-nine companies, and the chairman of ten at least. He was born in London, the eldest son of Samuel Beale, solicitor to the Midland Railway Company, and was educated at Harrow and Cambridge. At the University he read law. In 1899 he was admitted solicitor and joined his father's firm, of which he became junior partner a few years later. In 1919



SIR JOHN BEALE

he retired from the firm on his appointment as deputy chairman of the Midland Railway Company, a position which he retained until the amalgamation, but he remained on the board of the L.M.S. During the war his business capacity led to his appointment in 1916 to the Royal Commission on Wheat, of which he became deputy chairman in succession to Sir Alan Anderson. In the following year he was made Chairman of the Allied Wheat Executive. In 1918 he was knighted—K.B.E.—and was appointed the First Secretary to the Ministry of Food, and in the next year he represented, with Lord Reading, this country on the Allied Supreme Council of Supply and Relief.

We mention all these activities to show what manner of man Sir John was. In some of them he made contact with the engineering industries, but it was not till some years after the war that he became directly associated with them. In 1928 he succeeded Lord Buckland as chairman of Guest, Keen and Nettlefold, Ltd., and there fell to him the negotiations which led to the amalgamation of that firm with Baldwins, under the style British (Guest, Keen, Baldwins) Iron and Steel Company, Ltd., of which he became and remained till his death chairman and managing director. He effected, also, the amalgamation of the Powell Duffryn Steam Coal Company and the Welsh Associated Collieries, with a total capital of 17 million pounds. Amongst other interests of a more or less engineering nature with which he was associated, we may mention L. Sterne and Co., Ltd.; Universal Grinding Wheel Company, Ltd.; Orconera Iron Ore Company, Ltd.; Bayliss, Jones and Bayliss, Ltd.; Forth Bridge Railway Company; John Lysaght, Ltd.; and several collieries. Finally, we must not forget to mention the important part he played in the formation of the British Iron and Steel Federation last year. He was a Vice-President of that Federation.

As may be guessed from what we have said, by those who had not personal acquaintance with Sir John, he was a stout believer in the rationalisation of industry, and we may add that from the first he was one of the most active protagonists of import duties on iron and steel. His influence was widespread, and he held it because he was worthy of it. No man can be chairman of so many companies as he unless he has at once charm of manner and reasonableness, combined with firmness of character and steadfastness of purpose. When to these high qualities is added business capacity out of the common, we have men like Sir John Beale who leave behind them deep regrets at the passing of friends and uncertainty as to who is able to fill the gaps they leave; who will succeed them?

ALFRED SAXON.

MR. ALFRED SAXON, whose death occurred suddenly at his home in Manchester on December 3rd, at the age of seventy-six, was one of the brothers Saxon who, under the title of George Saxon, Ltd., were well known in Lancashire and abroad as the builders of stationary steam engines. On leaving Owens College, Alfred entered his father's works at Openshaw, and in 1887 he took over their management, his father and eldest brother George having died previously. He became governing director when the business was converted into a limited liability company. During this period the firm earned for itself a high reputation as one of the leading builders of stationary engines and millwrights' work, and many examples of its products are to be found in the cotton mills of Lancashire and abroad. Alfred Saxon took a prominent part in engineering circles in Lancashire and contributed freely to the papers and discussions of the engineering societies, particularly to those of the Manchester Association of Engineers, of which he was a past president. He was also past chairman of the North-Western Branch of the Institution of Mechanical Engineers, and a member of the Institution of Civil Engineers and the Iron and Steel Institute.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

GEARED LOCOMOTIVES.

SIR,—I would like to thank you for the very kindly criticism of my ideas on geared locomotives contained in your leading article last week, and to ask for space in which to make a reply.

First, the gear-box. There is on a standard gauge engine a clear space of, say, 4ft. 3in. between the inner faces of the tires. What I had in mind was a three-shaft arrangement in which the first, the crankshaft of the engine unit, drives through a fixed gear on to a lay shaft, having three sliding gear wheels engaging individually at will with wheels on a jack shaft extending beyond the ends of the casing and carrying cranks at its extremities coupled through side rods to the usual crank pins on one of the pairs of coupled wheels, or, better still, to a point on the side rods somewhere between two crank pins, on the assumption that such a point will have less vertical movement due to irregularities of the track. The deciding factor appears to be the lay shaft. If we allow for gear wheels of 6in. face, which I think ample, this shaft must carry one fixed and three sliding wheels, the latter requiring, say, 6½in. each for neutral position in addition, or 3ft. 7in. in all approximately. Changing can be effected through the shaft itself, if made hollow, and of sufficient diameter, and the end bearings can be arranged to project outside the casing between adjacent coupled wheels. This would leave 8in. for the thickness of the casing itself and for an intermediate bearing, which might be advisable. I should deprecate placing the gear-box on an axle, on account of the additional unsprung weight.

As regards turning moment, consider as an example a 1·2 gearing which would give at the periphery of the driving wheel with a three-cylinder engine (always my ideal) twelve lesser impulses per revolution in lieu of the six greater of the usual arrangement. It is the lessened impulse that reduces slipping, as witness the usual practice of a driver on a bank with a heavy train on a slippery rail, who works his engine in full gear with a very wire-drawn steam supply (partially closed regulator) in order to get a more even turning moment.

Coming to sizes of engines, I suggest that, with the exception of small branches and suburban services, any group in this country could be economically worked with three sizes of three-speed power. It is true that at times the unit would be over-boilered, but this happens already, and is a very good fault.

I would, in conclusion, venture to suggest that the steam locomotive is not holding the place that it should, observing the state of the building industry and the increasing use of the I.C. engine and electrification. I travelled yesterday to the coast by a new electric train, and could not help contrasting the very noisy and uncomfortable riding of the coach with the quiet comfort of a similarly modern steam train. As speeds have not been increased, all the advantage of the electrical service lies in its regularity of interval, but this would have been as easy with steam trains, and would have avoided the heavy capital expenditure of the former. It would seem that by arranging suitable gears any speed within reason could be attained by modern steam power.

YOUR CORRESPONDENT.

December 9th.

IN a paper before the Institute of Fuel and the Association of Gas Engineers, at Manchester, Mr. J. E. White gave the results of furnaces for the carbonisation process heated by gas and electricity. Compared with gas at 8·8d. per hour, or 0·79d. per pound of the product treated, the electrical costs were 12·3d. per hour, or 0·113d. per pound of treated product.

Extended Expansion in I.C. Engines.

By EDMUND GIFFEN, Ph.D., M.Sc., A.M.I. Mech. E.

AT the Spring Meeting of the Internal Combustion Engine Group of the Institution of Mechanical Engineers, a "Symposium of Papers on the Gas Engine as a Competitor in the Power Field" was presented and discussed. One point which was strongly emphasised was the comparative lack of progress in the development of the gas engine in recent years, owing, no doubt, to the success of the high efficiency oil engine. It was clearly brought out, however, that there are still many applications for which the gas engine is the most suitable prime mover, and many references were made in the discussion to the desirability of improving the efficiency of this type of engine. The object of the present article is to examine one method by which this may be done, viz., by using the extended expansion cycle, and to discuss, in the light of experimental results, a simple arrangement by which the cycle may be applied in practice.

It has long been recognised that, in petrol and gas engines operating on the Otto cycle, there is available in the products of combustion, at the end of the expansion stroke, quite a large amount of heat by which further work might be done on the piston, if only the expansion could be extended. Efforts have been made, notably by Atkinson about the years 1885 and 1887, to design an engine in which this increased expansion is possible, but so far without commercial success.

The pressure-volume diagram of the extended expansion cycle is shown at A B C D F in Fig. 1. A B C D E B is the corresponding Otto cycle, and the area E F B represents the additional work which may be obtained by continuing the expansion down to atmospheric pressure. Although this increases the work obtained from a given quantity of fuel, it also increases the size of the engine, the swept volume increasing from A B to A F. Thus, with any method by which additional work is obtained at the low-pressure end of the diagram, an increase in efficiency must be accompanied by a reduction in mean effective pressure, and therefore both of these quantities must be considered together. In practice, the expansion would be terminated at some volume G H, beyond which the increase in the size of the engine would more than cutweigh the gain in efficiency.

Considering the diagram A B C D G H (Fig. 1), it will be seen that the difficulty, from the point of view of engine operation, lies in the different swept volumes during suction A B and exhaust H A. In the engines designed by Atkinson* and others,† various special mechanisms have been introduced to obtain the required variation in the piston stroke during suction and exhaust, but the mechanical difficulties introduced in any such arrangement have so far prevented its general adoption in practice.

The cycle of operations considered in this article is shown by the diagram A B C D E F G in Fig. 2. This involves no radical change in engine construction, but only a modification of the arrangements for controlling the charge weight. The diagram shown may be obtained on an engine by causing the inlet valve to close at the point B, and allowing the charge to expand, as shown by B C, as the piston moves out to the end of the stroke. The compression, expansion, and exhaust then take place under normal conditions. The expansion along B C and subsequent compression along C B cancel each other out, so that the effective volume at the beginning of compression from atmospheric pressure is A B, and the effective diagram is A B D E F G. The effective ratio of compression, V_B/V_D, would be chosen, as at present, so that it has the highest possible value consistent with the absence of detonation. The corresponding Otto cycle is shown by the diagram A B D E H B, the essentially similar conditions in the two cycles being the compression ratio and the mixture strength, giving the same lines B D and D E for both diagrams.

An alternative method by which the same result may be obtained is by throttling the incoming charge during the whole of the suction stroke. This is shown by the line A C in Fig. 2, and is the method commonly used at present to control the charge weight at reduced output. This method has the disadvantage that it introduces a loss of useful work, the suction pumping loss, represented by the area A C B, thus reducing the benefit of the increased expansion. Both of these methods will be considered in more detail later.

Before proceeding with actual engine tests, it is desirable to have some guide as to the order of the effects (upon efficiency and mean pressure in the present instance) introduced by the proposed changes. This preliminary information may be obtained from an examination of the ideal air standard cycles for the two cases considered. In Fig. 1 B C D E is the Otto cycle and B C D G H is the extended expansion cycle. The usual simplifying assumptions are made, viz., that the working substance is air of constant specific heat, and the expansion and compression operations are adiabatic. P, V, and T represent pressure, volume, and temperature respectively, and suffixes A, B, C, &c., are used to denote the points on the diagram to which P, V, and T refer.

Now the important quantities in this comparison of the two ideal cycles are the compression ratio V_B/V_C, the pressure ratio on combustion P_D/P_C, both of which must be the same for both cases, and also the expansion ratio V_G/V_D, applying only to the extended expansion cycle. A more convenient quantity than the expansion ratio is the ratio V_G/V_B, *i.e.*, the ratio of expansion divided by the ratio of compression. We shall denote this expansion/compression ratio by α, the pressure ratio on combustion by β, and the ratio of compression by r. Expressions

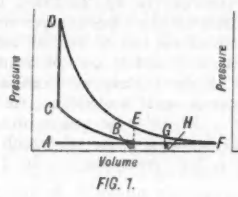


FIG. 1.

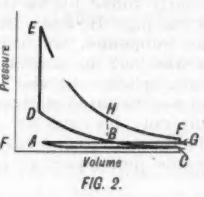


FIG. 2.

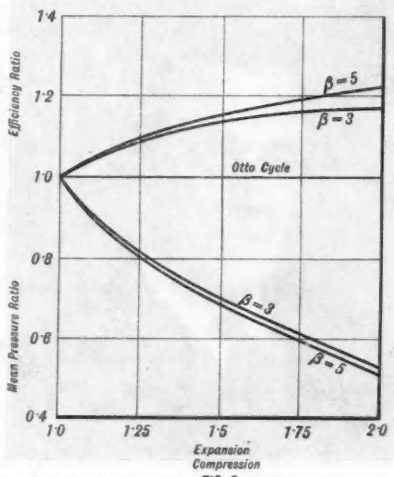


FIG 3.

for the efficiency and mean pressure of each cycle may readily be obtained in terms of these quantities, and are as follows :—

Otto Cycle.—

$$\text{Efficiency} = 1 - \frac{1}{r^{\gamma-1}}.$$

$$\text{Mean pressure} = \frac{P_B\,(r^{\gamma-1}-1)\,(\beta-1)}{(\gamma-1)\left(1-\frac{1}{r}\right)}.$$

Extended Expansion Cycle.—

$$\text{Efficiency} = 1 - r^{\frac{1}{\gamma-1}}\left\{\frac{\alpha\left(\frac{\beta}{\alpha^\gamma}-1\right)+\gamma(\alpha-1)}{\beta-1}\right\}.$$

$$\text{Mean pressure} = \frac{\frac{P_B}{\gamma-1}\left\{r^{\gamma-1}(\beta-1)-\frac{\beta}{\alpha^{\gamma-1}}+1\right\}-P_B(\alpha-1)}{\alpha-\frac{1}{r}}.$$

In order to compare the values given by these expressions, a case has been worked out for the following particulars :—Compression ratio, 5 ; α ranging from 1 (Otto cycle) to 2 ; two values of β, 3 and 5 ; $\gamma = 1{\cdot}4$. The efficiency and mean pressure of the extended expansion cycle have been expressed in terms of the corresponding values for the Otto cycle, and are shown plotted in Fig. 3. The two values of β were chosen to illustrate the effect of varying mixture strength in an engine.

It will be seen from the curves that as α (the expansion/compression ratio) increases, the efficiency increases and the mean pressure diminishes. This increase in efficiency does not continue indefinitely, but would reach a maximum when the expansion pressure reaches the initial pressure, as shown at F in Fig. 1 ; further expansion would result in a decrease in efficiency. For the curve representing $\beta = 3$ it is evident that, at $\alpha = 2$, the efficiency is approaching its maximum. The curve for $\beta = 5$ is still rising at this point, and would continue to rise until α reaches the value 3·16. For smaller values of α the curves for the two values of β lie closely together, showing that mixture strength may be expected to have but little effect upon the gain in efficiency as compared with the Otto cycle, except for greatly extended expansions.

The two curves for mean pressure also are quite close together over the range chosen. At higher values of α, after maximum efficiency has been passed, the mean pressure for the weaker mixture would fall away more rapidly.

From the shape of the curves of Fig. 3 a further point to be noted is that extension of expansion becomes less effective the farther it proceeds. For an increase of 25 per cent. in the cylinder volume ($\alpha = 1{\cdot}25$), the extended expansion cycle shows a gain of roughly 9 per cent. in efficiency and a reduction of 20 per cent. in the mean pressure as compared with the Otto cycle. For a further increase in α from 1·25 to 1·5, however, the gain in efficiency increases only from 9 to 15 per cent., and the decrease in mean pressure from 20 to 31 per cent.

These figures, although based upon certain simplifying assumptions, may yet be regarded as giving a fair indication of the results to be obtained from extended expansion. The numerical values of efficiency and mean pressure derived from the expressions given above will differ considerably from those obtained under similar operating conditions in an engine, but the assumptions which cause these differences may be expected to have similar effects in both the Otto and the extended expansion cycles. Thus for an engine working on the Otto cycle under certain conditions, and giving a certain efficiency and mean pressure, it may be said that, if the expansion be increased by, say, 25 per cent. ($\alpha = 1{\cdot}25$) without altering the compression ratio or other working conditions, the indicated efficiency should show an increase of the order of 10 per cent., and the mean pressure a decrease of the order of 20 per cent. of the original values.

Our considerations have so far been based on the indicator diagram, whereas in practice the brake performance is much more important. It is obvious that, for a given output, the extended expansion cycle will require a larger cylinder volume than is required for the Otto cycle. Further, the maximum pressures would be the same in both cases, so that no reduction could be made in the strength and weight of the working parts. It may be expected, therefore, that the mechanical losses would be slightly higher in the engine using extended expansion. If the induced charge is controlled by an early closing of the inlet valve, this slight increase in the mechanical losses is the only change to be expected as compared with the ordinary cycle, but if the charge is controlled by throttling during the suction stroke, then the increase in the pumping losses will further reduce the gain from the extended expansion. Thus it will be seen that the whole of the gain in indicated thermal efficiency cannot be expected to appear in the brake performance, and the amount which does appear will depend upon the method by which the extended expansion is applied, whether by induction cut-off or by throttling. It therefore appeared desirable to investigate the subject experimentally, and with this object the author carried out a series of engine tests in the Heat Engines Laboratory of King's College, London.

The tests were made on a single-cylinder horizontal Crossley gas engine, 7¼in. bore, 15in. stroke, using town's gas and running at a normal speed of 270 r.p.m. The compression ratio could be varied by inserting distance pieces between the end of the connecting-rod and the big end bearing. The normal method of power control is by throttling the charge during the suction stroke, the throttle consisting of a variable-lift inlet valve. The valve is operated from the cam shaft through a push rod and lever, and the fulcrum of this lever is variable and its position is under the control of the governor. The lift of the valve is therefore automatically varied to suit the load, but the period during which the valve is open remains approximately constant. At reduced output the variation in the valve lift introduces the required amount of throttling, so that the quantity of the charge is varied according to the load. The engine output was determined by means of a rope brake ; the gas consumption was measured by a dry meter, the calorific value of the gas being determined at suitable intervals. The air supply to the engine was measured by the air box and orifice method, a bellows box being inserted between the engine and the air vessel to ensure a steady flow through the orifice.

In the first series of tests the engine was run at different loads and at the highest overall compression ratio, the charge being controlled by the governor in the normal manner, by throttling during the suction stroke. At any reduced load the indicator diagram is of the form shown in Fig. 2, with suction taking place along the dotted line A C. As the load is progressively reduced A B becomes smaller, and the compression pressure (at B) decreases. These tests give results for a series of extended expansion cycles with different effective ratios of compression, but with a constant ratio of expansion. This throttling method of obtaining extended expansion was tried first because it involved no alteration to the engine.

A second series of tests was carried out to obtain comparative values for the Otto cycle under corresponding conditions. This consisted in testing the engine at full load at three lower values of the overall compression ratio, thus giving, when taken with the full load test in the first series, results for the Otto cycle at four different compression ratios.

In carrying out the first series of tests the gas control valve was fixed at one particular setting ; owing to the changing induction pressure at reduced

* "The Gas, Petrol, and Oil Engine," Clerk and Burls, Vol. 2, page 201.

† *Engineering*, Vol. CXXIV, page 613.

loads, however, the mixture strength did not remain constant during the series, but became weaker as the load was reduced. In the second series it was not practicable to adjust the gas control valve so that the mixture strength in each test would be exactly the same as at the corresponding point in series 1. The procedure adopted was to carry out each series of tests at three different settings of the gas valve, so that, by interpolation from the three sets of readings, corresponding values for the two methods of operation could be obtained at one constant value of mixture strength.

The test results for series 1 are given in Table I. The three sets of readings correspond to the three settings of the gas control valve. The quantities essential for the comparison with the Otto cycle are the b.m.e.p. and the brake thermal efficiency, while in order to ensure comparison under corresponding conditions the mixture strength and the compression ratio are also necessary. In tests with reduced charge weight the effective compression ratio, V_B/V_D (Fig. 2), is not so easily determined as the compression pressure, and anyhow the pressure at the end of compression is the really important quantity. In each of these tests the compression pressure was measured, and this is used as the basis of comparison for the two cycles. Table II gives similar results for series 2, the full-power tests at different compression ratios, from which the results for the Otto cycle are derived.

By suitable cross-plotting and interpolation from the data in Table I, Table III has been prepared.

TABLE I.—*Varying Load Tests; Overall Compression Ratio, 6·79; Control by Throttling.*

Set.	Test No.	B.m.e.p., lb./sq. in.	Brake thermal efficiency, per cent.	Mixture strength.	Compression pressure, lb./sq. in.
1	1	28·2	20·7	0·441	136
	2	36·9	23·0	0·453	151
	3	45·4	24·7	0·464	162
	4	53·9	26·5	0·474	170
	5	62·3	27·6	0·483	173
	6	65·7	28·4	0·485	175
2	1	28·3	20·0	0·538	124
	2	36·9	22·4	0·556	136
	3	45·4	23·9	0·572	147
	4	53·9	24·9	0·590	158
	5	62·2	25·8	0·605	166
	6	78·2	27·3	0·629	175
3	1	28·3	19·6	0·592	118
	2	36·9	21·7	0·631	131
	3	45·4	23·1	0·656	142
	4	54·0	24·2	0·674	151
	5	70·3	25·4	0·718	167

TABLE II.—*Full-power Tests at Different Compression Ratios.*

Compression ratio.	Test No.	Mixture strength.	B.m.e.p., lb./sq. in.	Brake thermal efficiency, per cent.	Compression pressure, lb./sq. in.
6·79	1	0·485	65·7	28·4	175
	2	0·629	78·2	27·3	175
5·86	1	0·553	67·6	26·0	142
	2	0·673	76·9	25·3	142
	3	0·767	76·6	24·1	140
5·04	1	0·556	65·0	24·2	120
	2	0·664	72·2	24·1	120
	3	0·816	77·0	23·2	120
4·67	1	0·627	66·1	22·9	102
	2	0·686	69·7	22·3	102
	3	0·723	74·4	22·3	102

TABLE III.—*Extended Expansion, Throttle Control; Mixture Strength, 0·6.*

Compression pressure, lb./sq. in...	130	140	150	160
Brake thermal efficiency, per cent.	21·5	22·8	24·1	25·2
B.m.e.p., lb./sq. in.	34·5	42·5	49·0	56·0

TABLE IV.—*Full Power, Otto Cycle; Mixture Strength, 0·6.*

Compression pressure, lb./sq. in. ..	175	142	120	102
Brake thermal efficiency, per cent.	27·5	25·8	24·2	23·1
B.m.e.p., lb./sq. in.	75·5	71·0	68·0	64·0

This gives, for the extended expansion cycle, values of brake thermal efficiency and brake mean pressure for various compression pressures, in all cases with a constant mixture strength of 0·6. In a similar manner, Table IV, giving the corresponding values for the Otto cycle, was derived from Table II. These results, showing the brake performance of the engine for the two cycles of operation under similar conditions, are shown in Fig. 4, plotted on the essential basis of comparison, compression pressure.

As regards the brake mean pressure, the curves show that, as would be expected, this is considerably less with extended expansion than in the corresponding Otto cycle. The efficiency, however, does not conform to expectations; the extended expansion cycle gives, under the conditions of these tests, a lower instead of a higher value than is given by the Otto cycle. Now the operation of the engine on the extended expansion cycle was effected in the present instance by throttling during the suction stroke. As the charge weight is continuously decreased, the indicated efficiency of the cycle should, up to a certain point, continuously increase, as compared with the Otto cycle; at the same time, however, the suction pumping loss, represented by the area A C B (Fig. 2), also continuously increases. Further, as pointed out earlier, the mechanical efficiency may be expected to be somewhat lower with extended expansion. It is evident from the efficiency curves of Fig. 3 that the extended expansion cycle, when obtained by throttling the charge, is even less efficient that the Otto cycle, any gain in indicated efficiency due to the increased expansion being more than offset by the increase in the mechanical and pumping losses introduced by the method of operation.

In order to eliminate this increase in suction pumping loss when the charge is reduced by throttling, a modification was made to the cam operating the inlet valve. A new cam profile was fitted, arranged to open the valve to its full lift, but closing the valve

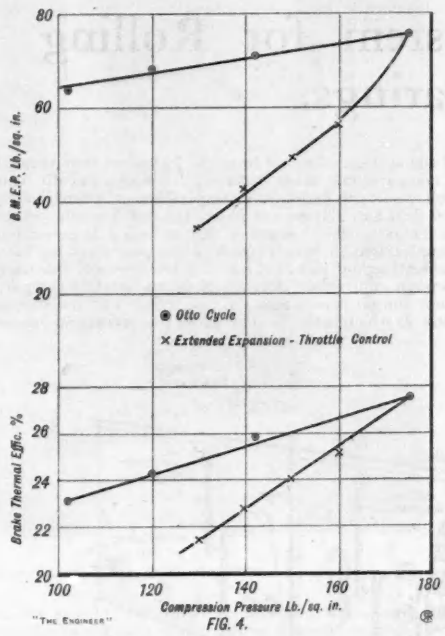


FIG. 4.

before outer dead centre. With this arrangement, and with the governor in its full-load position, the charge weight depends upon the point of closing of the valve, and the throttling loss is no greater than under normal full-load conditions. Tests were made with two new cams, cutting off the induction at 150 deg. and 120 deg. respectively after inner dead centre, thus giving results for the extended expansion cycle at two values of effective compression ratio. Fig. 5 is a reproduction of two light-spring indicator diagrams, taken with an optical indicator. The full line shows the conditions with the second new cam, closing 120 deg. after inner dead centre, in use, while the dotted line is from a diagram taken during the throttling tests, at a corresponding load. These diagrams show clearly the reduction in suction pumping loss following the use of the new cam.

With each new cam the engine was tested at its full output at different settings of the gas valve, so as to include the mixture strength at which the previous comparison was made. The results of these tests are given in Table V, and by interpolation from

TABLE V.—*Varying Mixture Strength Tests; Control by Induction Cut-off; Overall Compression Ratio, 6·79.*

Series.	Test No.	Mixture strength.	B.m.e.p., lb./sq. in.	Brake thermal efficiency, per cent.	Compression pressure, lb./sq. in.
1	1	0·419	37·4	24·8	122
	2	0·505	46·5	26·2	
	3	0·621	54·1	26·0	
	4	0·730	60·8	25·7	
2	1	0·467	28·5	23·3	82
	2	0·525	32·0	23·8	
	3	0·606	37·0	24·4	
	4	0·689	40·6	24·1	

TABLE VI.—*Extended Expansion, Control by Induction Cut-off; Mixture Strength, 0·6.*

Compression pressure, lb./sq. in.	122	82
Brake thermal efficiency, per cent. ..	26·1	24·3
B.m.e.p., lb./sq. in.	53·0	36·5

these figures Table VI has been prepared, giving the compression pressure, efficiency, and brake mean pressure for the two new cams at a mixture strength of 0·6. These two sets of results for the extended expansion cycle can be associated with that for the normal cam at full output, since the latter corresponds to the limiting condition where the compression and expansion ratios are equal ($\alpha=1$). Fig. 6 shows the results plotted and compared with those from Table IV for the Otto cycle.

The most important point about the curves in Fig. 6 is the definite improvement in efficiency for the extended expansion cycle; the b.m.e.p. is less than in the corresponding Otto cycle, as may be expected. The compression pressure with the second new cam was lower than with the lowest overall compression ratio, so that the curve for the extended expansion cycle covers a greater range than that for the Otto cycle. Taking the lowest point on the Otto cycle, however, it will be seen that extended expansion shows an improvement of almost 10 per cent. in efficiency, with at the same time a reduction of 28 per cent. in b.m.e.p., as compared with the Otto cycle results. The extension of the expansion in this particular instance is from a compression ratio of 4·67 to an expansion ratio of 6·79, giving an expansion/compression ratio of 1·46. This degree of extended expansion would have been obtained by the use of a cam causing the valve to close about halfway between 120 deg. and 150 deg. after I.D.C.

In Fig. 3, which gives comparative results for the two ideal cycles, it will be seen that for a value of $\alpha=1·46$, the extended expansion cycle, when $\beta=3$, shows a gain in indicated efficiency of 13 per cent. and a decrease in indicated mean pressure of 28 per cent. Thus the test results bear out the suggestion made earlier, that a consideration of the ideal diagrams should give a fair guide as to the comparative results to be expected in practice from the two cycles. They also show that, in an engine in which the charge is reduced by induction cut-off, and when the reduced

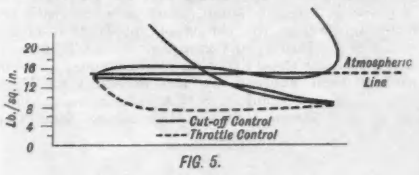


FIG. 5.

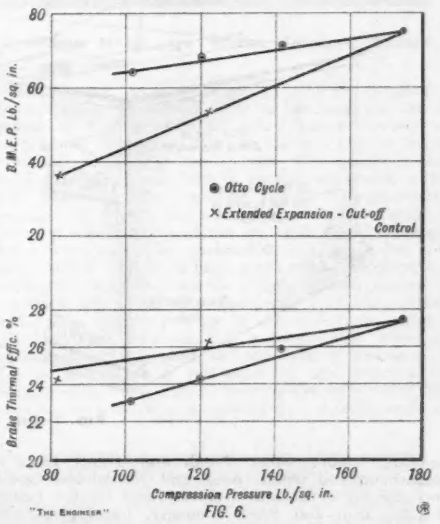


FIG. 6.

mechanical efficiency is taken into account, the full benefit to be expected from extended expansion may actually be obtained.

The results of the tests with induction cut-off show that the extended expansion cycle may, in fact, be applied to an engine without introducing any additional complication in the mechanism. The only change as compared with operation on the Otto cycle is that the inlet valve is arranged to close at some point in the suction stroke, this closing point determining the amount by which the expansion ratio exceeds the compression ratio. In designing an engine to work on this cycle the effective compression ratio would be made as large as possible, consistent with the absence of detonation; the extension of the expansion, which determines the point at which the inlet valve is to be closed, would be chosen so as to give a satisfactory compromise between increased efficiency and reduced mean pressure, according to the particular application of the engine. This would fix the expansion ratio.

When working at reduced load two alternatives are available for controlling the charge weight. Either this may be done as at present, by throttling during the suction stroke, or the induction cut-off method may be applied, by varying the closing point of the inlet valve. With the latter method the crank angle at which the valve closes would be under the control of the governor, operating through a variable cam or some such suitable arrangement. In this way the increased pumping losses at reduced load might be eliminated and the brake thermal efficiency correspondingly increased. The extent of the benefit to be derived from this source has been considered in detail in an earlier paper;‡ it is only mentioned here in order to bring out the point that induction cut-off provides a possible method of power control as well as a simple and satisfactory arrangement for applying the extended expansion cycle under full-load conditions.

The conclusions from the above investigation may be summarised as follows:—

1. It has been shown that an engine working on a

‡ *Engineering*, August 24th, 1934.

reduced charge is, in effect, using the extended expansion cycle.

2. Test results show that, when the reduction of the charge is effected in the normal manner, by throttling during the suction stroke, the overall efficiency falls below that for the corresponding Otto cycle.

3. When the valve gear is modified so that the charge is controlled by the early closing of the inlet valve, the increased suction pumping loss due to throttling is eliminated, and the engine, working with extended expansion, shows a definite improvement in efficiency as compared with the Otto cycle.

4. The performance of the engine with extended expansion, when this is obtained by the induction cut-off method, is, as compared with the performance on the Otto cycle, approximately of the order suggested by a consideration of the ideal air standard cycles for the two cases.

5. Finally, the test results show that the proposed simple method for obtaining extended expansion gives satisfactory results in its practical application, and offers a means of improving the efficiency of an engine without introducing any mechanical complications.

In conclusion, the author would record his indebtedness to Professor Gilbert Cook and to the Delegacy of King's College, London, for the facilities placed at his disposal in connection with the experimental work involved in this investigation.

Pressure Oiling System for Rolling Mill Bearings.

THE oil-pressure-lubricated bearings and gears now coming into use in steel works practice require the use of equipment for circulating and for purifying the oil. No defect, large or small, must interfere with the continuity of supply, for the whole production of the mill would be held up by any stoppage.

In order to meet these exacting requirements, a special system has been evolved by the Stream-Line Filter Company, Ltd., of London, S.W.8, which has already completed installations for the Lancashire Steel Corporation, Irlam; Steel, Peech and Tozer, Ltd., of Rotherham, and Guest, Keen and Nettlefolds, Cardiff (two plants), whilst others are in hand for the British (G.K.B.) Iron and Steel Company, Cardiff, and the Templeborough Rolling Mills, Rotherham. Illustrations here reproduced show one of these installations, whilst the description which follows applies broadly to all of them.

The main components of the oiling system are a storage tank, a pressure tank, filters, pumping machinery, and the oil pipe mains, drain lines, fittings, and supports. The oil returned by gravity from the mill enters the storage tank, which is placed at the lowest point in the system, usually in a cellar. This tank is of large size, containing as much as 10,000 gallons in the case of the largest plant yet supplied. The arrangement of this storage capacity in such a way as to ensure as much purification as possible by settling is an essential feature of the system. The oil from the mill flows first through a compartment fitted with coils thermostatically controlled so as to maintain a temperature of approximately 100 deg. Fah. Thence it passes through a mesh strainer to remove coarse impurities and so into a large settling compartment, in which specially designed trays facilitate the settling out of water, which is removed automatically through an overflow device. From the settling compartment the oil passes into the last division of the storage tank, in which is the suction line to the circulating pumps.

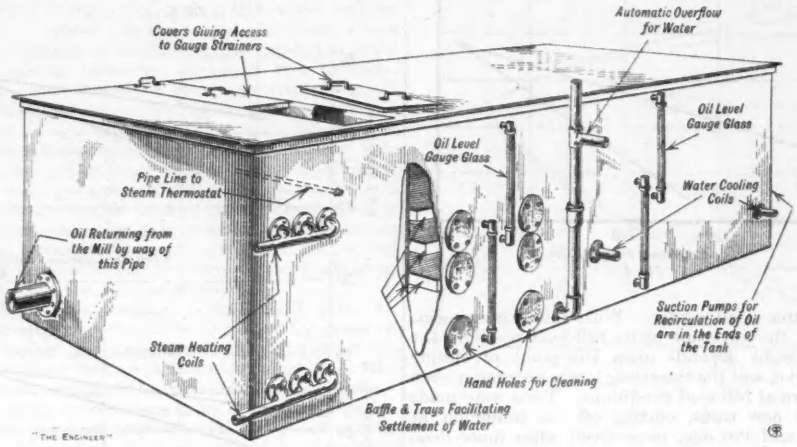

Covers Giving Access to Gauge Strainers
Automatic Overflow for Water
Oil Level Gauge Glass
Oil Level Gauge Glass
Pipe Line to Steam Thermostat
Water Cooling Coils
Oil Returning from the Mill by way of this Pipe
Suction Pumps for Recirculation of Oil are in the Ends of the Tank
Steam Heating Coils
Hand Holes for Cleaning
Baffle & Trays Facilitating Settlement of Water
"THE ENGINEER"

FIG. 1—OIL STORAGE TANK

Fig. 1 shows the arrangement of a typical storage tank, while Fig. 4 gives a lay-out for a typical pipe circuit.

The oil, freed from coarse impurities and water by straining and settlement of the whole flow, and from finer impurities by by-pass filtration as described later, is picked up by one of the oil-circulating pumps and delivered into the pressure tank. There are two of these pumps so as to provide a standby, and if one should be closed down for inspection or suffer a mechanical breakdown, the other comes into operation automatically. Fig. 3 shows a pair of circulating pumps with shut-off and non-return valves.

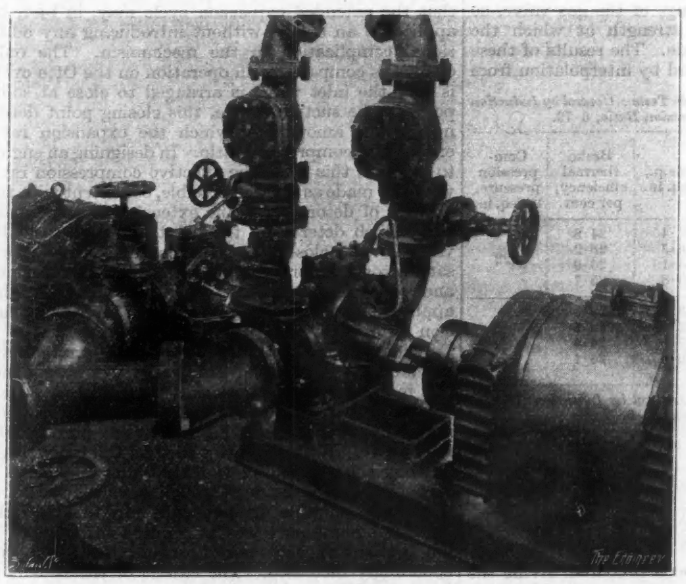


FIG. 3—OIL CIRCULATING PUMPS

The pressure tank is shown in Figs. 2 and 4. It is of the vertical cylindrical type and of considerable capacity, amounting to 5000 gallons in the case of a large system. In it a cushion of compressed air is maintained under a pressure of 25 lb. to 40 lb. per square inch, which forces oil to the bearings under adequate pressure for several minutes even if the pumping system is put temporarily out of action. The margin of minutes thus given is of vital importance, as it enables the mills to finish off billets already in train before closing down.

The oil pumps normally maintain the air cushion by supplying oil to replace that fed to the bearings. Pressure switches cut a pump in or out as necessary when selected high and low limits of pressure are reached. If air is carried into the tank with the oil so that an excessively large air cushion tends to be formed, it can be released by means of a suitable valve. If, on the other hand, air is lost from the tank for any reason it can be replaced by opening a compressed air connection. An electric gong—see Fig. 2—gives a warning if the oil level tends to pass beyond predetermined limits.

From the pressure vessel the oil flows to the bearings through the pressure-regulating valve seen in Fig. 2,

FIG. 2—PRESSURE TANK

which maintains constant conditions at the bearings in spite of the periodic fluctuations in the vessel. After lubricating the bearings the oil flows by gravity back into the storage tank.

The purification of the oil is accomplished by three distinct processes, all of equal importance. In the first place, the whole flow is continuously relieved of coarse impurities and bulk water by sedimentation in the storage tank as already described; secondly, some 10 per cent. of the flow is by-passed through a bag-type filter which removes a large proportion of the finer impurities; thirdly, a relatively small percentage of the flow is by-passed through a stream-line edge filter of the Hele-Shaw type.

An independent pump with a duplicate in reserve withdraws oil from the outlet end of the storage tank and delivers it into the bag-type filter, the rectangular vessel in Fig. 5, through which it flows under a gravity head of only a few inches and thence back into the storage tank. The bags, which are of special weave, are stretched on wire mesh frames, and the oil flows from the outside to the inside, passing out by way of a separate nozzle for each bag. A number of separate compartments accommodate the bags, so that one may be drained and the bags therefrom cleaned, without interfering with the flow through the other bags.

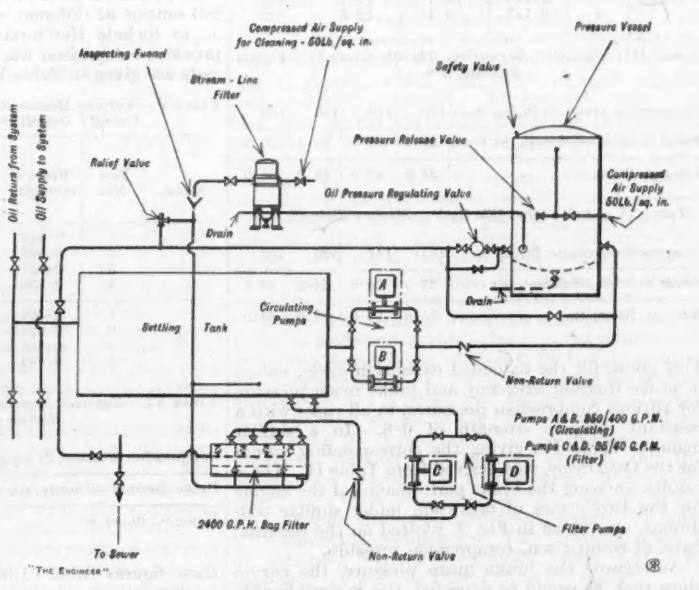


FIG. 4—TYPICAL LAY-OUT OF OILING SYSTEM

the same as would be achieved by bag filtration of the whole of the oil once every eight or ten hours, whilst the stream-line filter removes the finest particles. Without the employment of such a filter the condition of the oil would necessarily become progressively worse owing to the accumulation of fine particles. A filter which removes all impurities from the oil treated, even though its output appears disproportionately small, effectively prevents any such cumulative effect. That a filter dealing with only 20 or 30 gallons per hour in a system circulating 15,000 gallons per hour could produce satisfactory equilibrium in the oil condition would seem impossible to anybody unfamiliar with the by-pass filtration practice adopted in connection with Diesel engine lubrication.

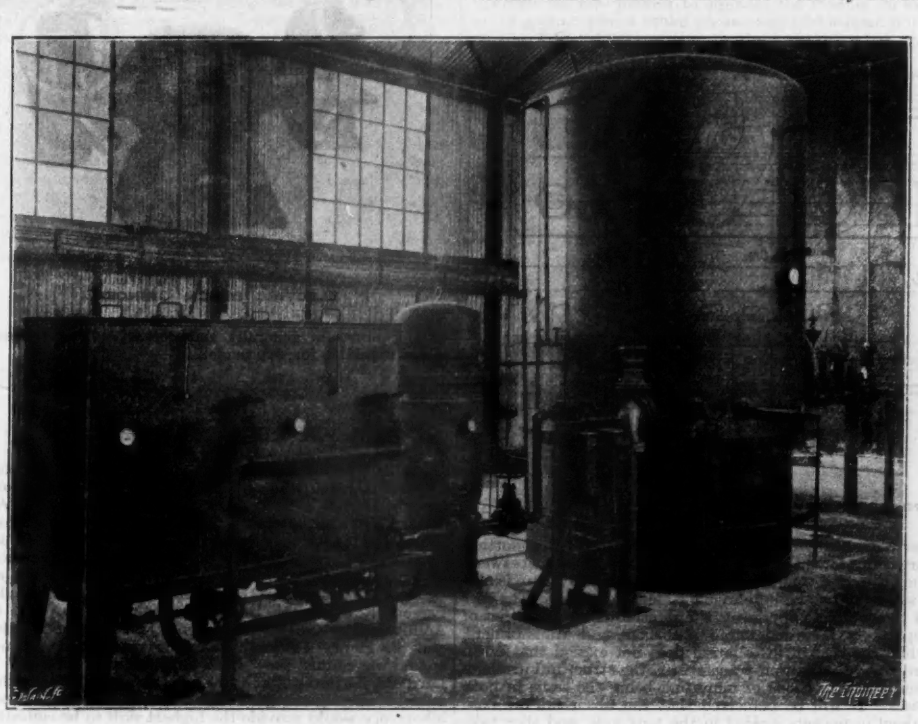


FIG. 5—PRESSURE TANK AND STREAM-LINE AND BAG FILTERS

As may be seen from the run of piping in Fig. 4, the stream-line filter seen in the centre of the engraving is connected to the pressure vessel, so that oil is by-passed under pressure from this vessel, and drains back in its purified state into the storage tank. Compressed air is always available in the system for cleaning the filter by reversal.

The figures given below, supplied to us by the makers, relate to the largest installation of the kind described yet put into operation :—

Lancashire Steel Corporation—Mill Oiling System—Irlam.

	New oil.	Samples from circulating system.	
		After six months.	After two years.
S.G. at 60 deg. Fah. ..	0·896	0·896	0·898
Viscosity at 100 deg. Fah.	800	805	930
,, 130 ,,	338	344	364
,, 210 ,,	77·8	78	79
Acid value as SO_3	—	0·006	0·028
Water, per cent.	—	0·02	Immeasurably small trace
Impurities		Nil	Nil
Sludge		Nil	Nil

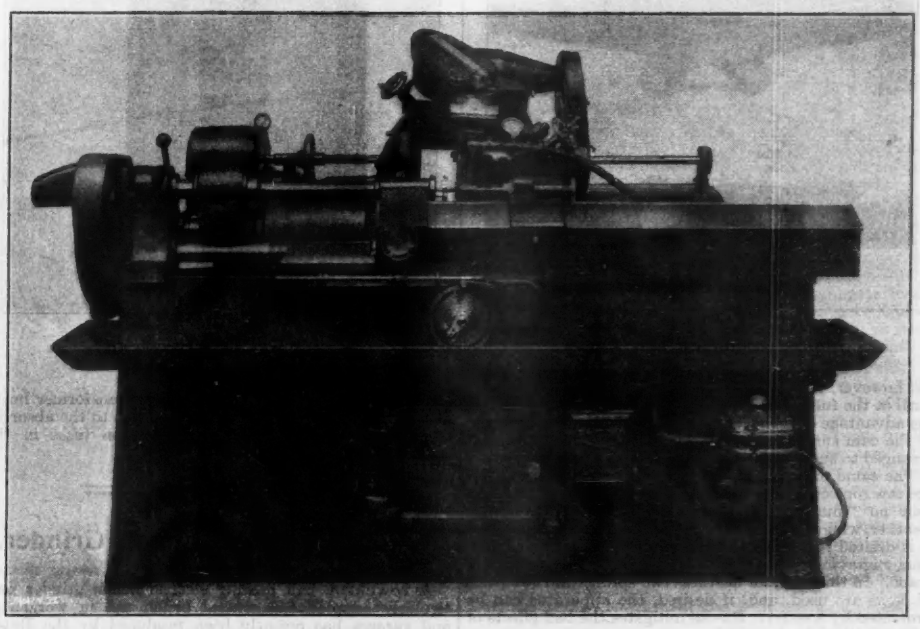
It should be noted that the samples analysed were taken from the circulating system, not from one of the filters; hence, they genuinely represent the condition in which the whole bulk of the oil is maintained by the processes described.

A Thread Grinder.

RESEARCH in thread grinding has led to the adoption of two fundamental principles in the design of thread grinding machines. One process uses a multi-ribbed wheel, the material being ground by taking a full-depth cut with slow work rotation. The other process makes use of a single-ribbed wheel, the material being removed by a series of light cuts at a high speed. This latter principle is adopted in the range of thread grinders originated by Atkins (Peterborough), Ltd. The works and business of this firm have recently been acquired by the Newall Engineering Company, Ltd., which will continue the manufacture of the machines and the tools are being marketed by Alfred Herbert, Ltd., of Coventry.

Extensive experience in the design and application of these machines has proved, it is said, that by taking light cuts at high speed the strains that are always present in hardened work are released gently and consequent errors are rectified as they are released. A higher degree of accuracy and greater production are obtainable with the light-cut method than is possible with the heavy cut method. There is also less wheel wear and therefore less wear on the diamond dresser. The Newall machines utilise both single and multi-ribbed wheels. The single-rib wheel is used for work such as thread gauges, which are dealt with only in small quantities, whilst for large-quantity production a multi-ribbed wheel, still using the light-cut method, will give an increase in output.

One of the most important features of the Newall thread grinder is the patented wheel dressing device, which we described fully and illustrated by drawings in a Supplement at the time of the Machine Tool Exhibition last year. The wheel is dressed by a wrought diamond, rectangular in shape for the single-rib wheel dresser and chisel shaped for the multi-rib dresser. This diamond is mounted in a holder in such a way that it can be reversed when worn and still maintain its cutting rake. It is important to note that the diamond is used as a cutting tool and shaped accordingly with its correct rakes and cutting angles. Diamonds in their natural form or circular formed diamonds dress the wheel by abrasion, and the same finish cannot be obtained, whilst any gain from the harder skin of the natural diamond is more than compensated by the reversibility of the wrought diamond. The diamond is magnified many times (usually twenty-five) on a projector, and an adjustable steel stylus is set to the profile of this magnification. There is also prepared a former, which is a reproduction of the thread to be ground, to the same magnification. The dressers carry the diamond, the stylus and the former in such a way that when the stylus is traced round the former the diamond is traced across the wheel with an exactly similar motion on the reduced scale. The change over from one thread to another is merely a matter of changing the former, and the redressing of the wheel only takes a few seconds, and is done without removing the work or upsetting the adjustment of the machine. Various forms of the dressers are made for Whitworth, Acme, and worm threads.



AUTOMATIC THREAD-GRINDING MACHINE

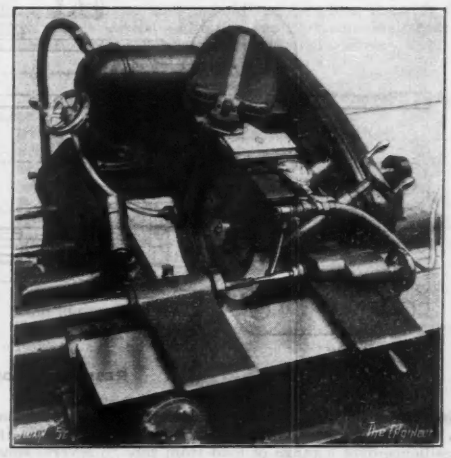
At the present time the Newall Engineering Company are building two sizes of machine.

The N.S. 4 is a very handy thread-grinding machine for screw gauges, taps, reamers, and small general engineering work. It has a 10in. diameter grinding wheel and will grind pitches from forty per inch up to six per inch Whitworth.

The N.S. 10 automatic thread-grinding machine, which we illustrate, has been designed to meet the demand for a machine capable of carrying equipment for a great variety of work. It can grind right or left-hand taps, including boiler stay taps, with any number of flutes, straight or spiral relieved, Whitworth, metric, or Acme form; screws of Whitworth or Acme form with single or multi threads; worms of any pressure angle with single or multi threads, square or rounded corners; thread hobs with annular grooves or spiral, single or multi threads, with straight or spiral flutes; gear hobs up to its capacity with straight or spiral flutes.

The maximum grinding length is 20in., and the tool takes 36in. between centres. The work spindle has a 1in. hole through it, and is provided with a collet chuck. The maximum diameter that can be ground is 4in., and the machine can be made to grind short lengths 6in. in diameter.

The pitch is obtained from a lead screw and change wheels, provision being made for right and left-hand work. The lead screw is 2in. diameter with a hardened and ground thread, which carries an N.P.L. certificate. Division for multi-thread work or annular grooves is obtained by a ground worm actuating on an accurately cut worm wheel. The wheel head on this machine is driven by an A.C. motor with two speeds. The spindle is hardened and lapped, and runs in parallel adjustable white metal bearings. The endwise thread is particularly accurate. The thrust plates are integral with the spindle. These are also lapped and run on white metal bearings. Twelve work speeds are obtained from compounded belt cones. When required, a back gear can also be provided, doubling the number of speeds. The automatic reverse is at a fixed high-speed rate, independent of the cutting speed. The traverse motion is obtained from hydraulically actuated clutches, and is particularly sweet in action, even at high speed, and the point of reverse is of great accuracy. It is self-adjusting and requires no attention other than that of keeping the oil level of the clutch box to a mark on a sight gauge. A helix angle of 15 deg. is obtained right or left hand by swivelling the wheel head slide, motor and dresser bodily in a cradle by means of a graduated dial. The wheel dresser illustrated has a capacity up to six per inch Whitworth, and is for single-rib wheels; but larger or smaller dressers can be supplied and also dressers for multi-rib wheels or combined multi and single wheels.

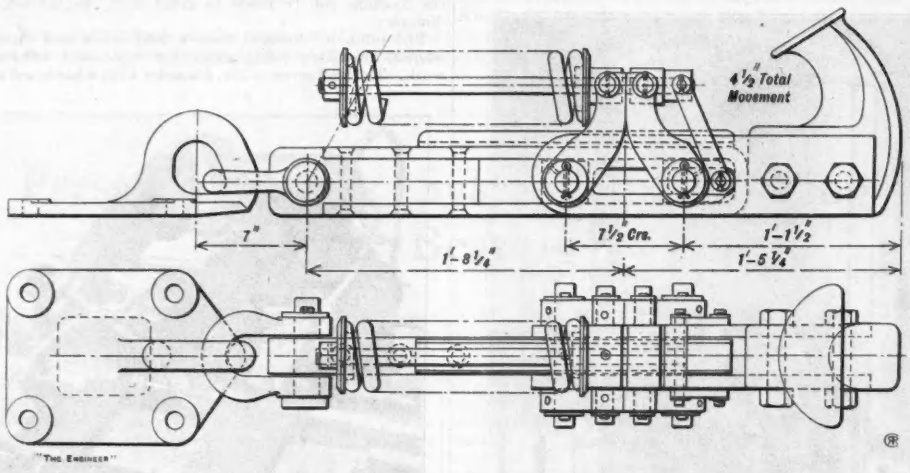


GRINDING HEAD AND WHEEL TRUEING DEVICE

An Industrial Shock Absorber.

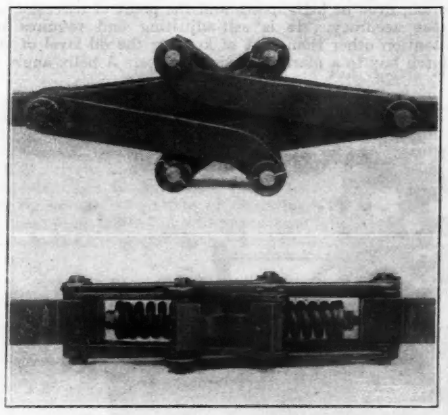
THE use of shock absorbers is not confined to the suspension of motor cars. Many other applications can be found for them frequently where the loads to be borne

are very much greater. The engravings on this page show two applications of a device designed by the Monarch Controller Company, Ltd., of 7, Victoria-street, Westminister. When a ship is moored to a quay the effects of the tide or of waves or the wash of a passing vessel may cause the mooring ropes to "snatch," thus throwing very heavy loads upon them and leading sometimes to breaking. The principle of the device shown in the drawing is to relieve the heavy load by the use of spring resilience, which will absorb the shocks. The spring is, however, not inserted directly as a link in the mooring rope, since that arrangement has several disadvantages, the chief of which



RESILIENT BOLLARD FOR QUAY

are that if the spring should break the rope parts, and that a suitably compact spring cannot be made to retain its resilience over a range of load from zero to several tons. The apparatus illustrated is erected on the quay, to which it is attached by an eye and link. The mooring hawser is slipped over the hook on the right, which carries one of a pair of pins on which cam-shaped pieces are mounted; whilst the other pin is carried on that part of the device which is linked to the quay. Thus when a pull is exerted by the hawser, the two pins are caused to approach, with the result that the two cam surfaces roll over one another and cause the spring to be compressed. A link holds the spring rod parallel with the main member of the apparatus. Obviously with this arrangement breakage of the spring will not cause the link to part, as the two pins will come together and will transmit the load. Less obviously, the effect of the cam surfaces is to allow a short and light spring to retain resilience at all loads. In the unloaded condition shown in the drawing the load has a mechanical leverage over the spring of about 6 to 1.



SHOCK ABSORBER FOR CRANE

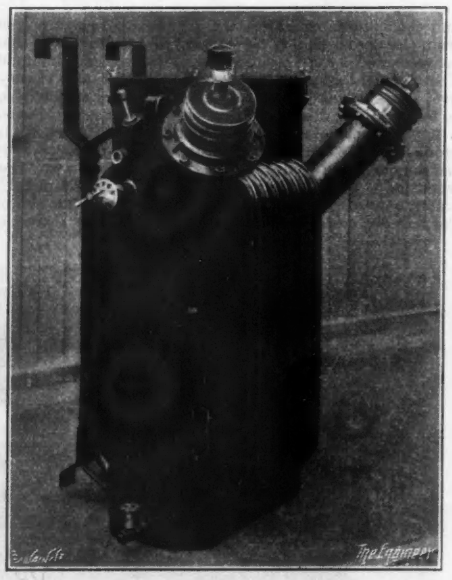
As, however, the load is increased this leverage is reduced until at the fully loaded condition it is the spring that has the advantage over the load. By modification of the shape of the cam surfaces, the resilience at any loading can be arranged to suit any special circumstances that may exist.

The same principle has been applied on tugs to relieve the tow rope of unnecessary stresses, and it has been found that no "nursing" of the tow is necessary in rough weather, while a "jerk" can be applied to the rope when it is desired to release a ship that has run aground. The tone engravings show another application, this time to a crane. In this case, for neatness two springs and two pairs of cams are used, and, if desired, the apparatus can be protected by a cover. Its use mitigates the bad effects of a "snatched" load.

Surge-Proof Transformers.

THE Ferranti surge absorber for protecting transformers and other inductive apparatus from lightning and switching surges is now in use in many parts of the world, and most transmission engineers are probably familiar with its construction and principle of operation. Unlike the ordinary lightning arrester, it is connected in series with the line, usually at the entrance to a sub-station or at the transformer terminals, and as it does not discharge the surge to earth, large lightning stroke currents are not essentially destructive, the absorber being ready for service again after the occurrence of such a stroke. Surge absorbers for small transformers associated with distribution circuits may be mounted on a pole carrying a transformer. Separate insulation must then be provided for the two separate units. Two high-voltage bushings are required for each absorber for the incoming and outgoing connections. But since the absorber is connected in series with the line and in the case of distribution substations is employed mainly for transformer protection, there is obviously no reason why it should not be combined with the transformer, as shown in the accompanying illustration, which represents a 50-kVA, 11,000-volt, pole-mounting transformer.

This new form of construction, recently developed by Ferranti, Ltd., offers appreciable advantages. Supporting structures for the surge absorbers and connections between the latter and transformer are eliminated, and there is also a saving of two high-voltage bushings per phase. The cost of the complete apparatus is appreciably less than that of separately mounted surge absorbers and transformers, while the cost of installation does not exceed that of an ordinary distribution transformer, the structural arrangements and methods of mounting being the same in both cases. It will be perceived that the absorbers are contained in pockets welded in the tank side, and they take

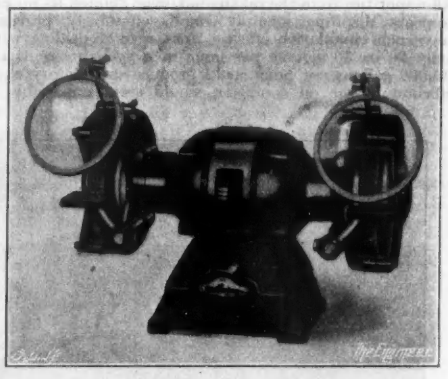


SURGE-PROOF TRANSFORMER

the place of the ordinary high-voltage transformer bushings. Connections from the overhead line to the absorber terminals are made through high-tension fuses in the ordinary way.

A Rotax Electric Bench Grinder.

A POWERFUL ball bearing electric bench grinder particularly adapted for general bench use in workshops and garages has recently been produced by the Rotax electric tools department as announced by Joseph Lucas, Ltd., Great King-street, Birmingham, 19. It has been designed in two sizes, 7in. and 6in. diameter, of which the larger is equipped with adjustable safety glass eyeshields, as illustrated, and tool rests adjustable to compensate for wheel wear. The wheel guards, which are made to accommodate wire brushes, are of the enclosed type, with removable end covers to permit "end" grinding and to facilitate brushing. A special pedestal is provided as an extra for use when bench mounting is not desirable, and has a combined water-pot. The motor is totally enclosed and is not universal. It is built for single-phase A.C. or D.C. to the standard voltages of 100/110, 200/220, 220/230, 240/250. Speeds on no-load are given as follows:—For 25 cycles A.C., 1500 r.p.m.; 40 cycles, 2400 r.p.m.; 50 cycles, 3000 r.p.m.; 60 cycles, 3600 r.p.m., and direct current 3000 r.p.m. The machine is supplied with one fine and one medium grinding wheel and is fitted with a control switch in the base. The 6in. model has no eyeshields and has a fixed tool rest. It is supplied for 100/110, 200/220, 230/250 volts on the same frequencies as the 7in. model, the speeds being the same. The wheel guards are of the open type on the 6in. model, and for use on the bench rubber feet are provided as



ELECTRIC BENCH GRINDER

bolting down is generally unnecessary. The pedestal is also available for this model.

THE L.M.S. RESEARCH LABORATORY.

ON Tuesday, December 10th, Lord Rutherford opened the new research laboratory of the L.M.S. Railway Company at Derby. The ceremony was performed in a novel manner from the special train drawn up in the laboratory siding, the speeches of Lord Rutherford and of Sir Josiah Stamp, president of the L.M.S. executive, who introduced him, being broadcast. The guests included Sir William Bragg, Sir James Jeans, Lord Ashfield, Chairman, London Passenger Transport Board, Sir Ralph Wedgwood, Sir Archibald Page, Sir John Cadman, Sir Harold Hartley, and Sir Henry Fowler. Before leaving London a new engine was named the "Lord Rutherford of Nelson" by Lord Rutherford's grandson, who was presented with a model of the engine. Sir Josiah Stamp stated that the new laboratory would provide the highest skill to be consulted by all departments of the organisation, but that no attempt was being made to supersede or rival other scientific efforts. The L.M.S.R. was still extending its use of outside facilities in connection with the Department of Scientific Research. Lord Rutherford stressed the importance of the connection between the company and the Department of Scientific Research, formed by the existence of such a laboratory in close contact with the practical everyday work of the railway. The new laboratory concentrates in one building the paint, metallurgical, textile, and engineering sections. Chemical work is undertaken in laboratories at a number of centres. A wind tunnel giving valuable data on running resistance is attached to the locomotive engineering shops. The work done at the laboratory includes some 8000 tests carried out on materials, while some 4000 samples of paints and varnishes are examined. A machine, claimed to be the only one of its kind in this country, tests the fire-resisting properties of paints. Suspension investigations are carried out in a van equipped with a film camera focussed on the rim of the wheel by means of a periscope.

CATALOGUES.

JAMES DAWSON AND SON, Ltd., Boultham Works, Lincoln.—A handbook dealing with "Speedona" V-ropes for short centre drives.

PYRENE COMPANY, Ltd., Great West-road, Brentford, Middlesex.—Particulars of the "Pylumin" system of protecting aluminium.

JOSEPH ADAMSON AND CO., P.O. Box 4, Hyde, Cheshire.—Details of the "Adamson" roller-bearing, totally enclosed, electric crane.

DAVID BRIDGE AND CO., Ltd., Castleton, Rochdale.—Catalogue B/N 35, illustrating and describing machinery for tire and tube manufacture.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, W.C.2.—A booklet on ironclad and all-insulated house service switchgear.

BRITISH ALUMINIUM COMPANY. Ltd., Adelaide House, King William-street, London, E.C.4.—Publications No. 367, a small pocket book of 180 pages, entitled "Aluminium Facts and Figures," and No. 37, entitled "Aluminium Architecture and Decoration."

FLAWLESS WELDING.—We are informed by Barimar, Ltd., of 14/18, Lamb's Conduit-street, London, W.C.1, that it has developed an arc welding process whereby it is now possible to build up worn shafts and similar parts of all weights and dimensions and machine them to the required size with a finish equal to that obtainable on unwelded metal. Hitherto it has not been easy to eliminate every trace of welding. This new method is carried out by surrounding the arc and the end of the feed rod with an "envelope" of hydrogen, which is released from the electrode coating or supplied from cylinders. This hydrogen excludes the atmospheric oxygen which was found to have an effect on the surface of the molten metal.

"THE ACCURATE MEASUREMENT OF TEMPERATURE."—A book bearing this title has been compiled and issued by the Cambridge Instrument Company, Ltd., 45, Grosvenor-place, S.W.1, with a view to grouping together in a comprehensive form all the essential information regarding the generally used methods of temperature measurement. The first part of the book deals with theory and application, and is followed by tables of constants and comparative tables compiled from authoritative sources. The second section of the book gives illustrations and details of the various types of temperature-measuring instruments ranging from the ordinary mercury-in-glass thermometer to optical pyrometers for the measurement of the highest temperatures. The book is issued at the nominal charge of 1s. 6d.

A Large Gold Dredger.

(By a Californian Correspondent.)

THE present high price paid for gold has stimulated the ingenuity of dredge designers. Under the old regime, the Yuba Goldfields, California, had reached its extinction point. The best ground had long been worked out and for many years only a few marginal areas remained and the final dredger was shut down in 1926, and its armies of workers dispersed into other countries.

But under the magic wand of governmental enactment, which set the price of gold at £7 an ounce, the impossible was accomplished, and the gold-dredging industry is thriving again. Engineers of the Yuba Company quickly delineated areas that could be worked with profit, and new operations were started. Much of the placer deposit lay deeper than had been worked previously, and to dredge this new ground a digging depth of 150ft. was necessary. To effect this, the old Yuba No. 17 dredger was dismantled

FIG. 1—GOLD DREDGER

and the parts were transported to the south side of the Yuba River, at which place the Yuba Manufacturing Company, of San Francisco, constructed the dredge shown in the illustration (Fig. 1) and which is believed to be the world's largest dredger.

The hull is of all-steel construction, 233ft. 9in. long by 68ft. wide and 11ft. 6in. deep. It is built of plates, angles, and channels, stiffened by two heavy trusses, one on each side of the well hole, running the entire length of the hull. Important departures from standard practice were required by reason of the great weight and range of the digging unit. The dimension of the bucket ladder called for assembling the steel at the site after previous erection and disassembling in the shops; 200ft. long between tumbler centres, it required a special device for decreasing the return line's catenary pull. By devising a proper relationship between digging and stacking, the possible interference of tailings with the work of cleaning up bedrock was avoided.

The weight of the hull and superstructure is 1300 tons, and some 75,000 lb. of rivets were required. The total weight of the digging system is 740 tons. The digging ladder, which supports the bucket line, is of the plate girder type, and is 200ft. in length between tumbler centres, thus constituting the largest ever used in the dredging industry.

Transportation difficulties were encountered, owing to the extreme depth of the girders, and the lower section, 64ft. in length, was put together on the ground, and the other portion, 136ft. in length, was erected in place, using cribbing for a foundation. Then the lower section was connected to the upper portion after the ladder suspension was installed. The ladder is supported at the upper end by bearings on the upper tumbler shaft. The idler on the underside of the ladder is 10ft. in diameter and weighs 40 tons.

On the line there are 126 buckets of 18 cubic feet capacity. They are of manganese steel, reinforced for the unusual loading upon them caused by the idler on the underside of the ladder. They are also equipped with a cast stop near the back eye to regulate the amount of backlash when passing over the idler. Lips are of the inside-outside type, riveted in place. Fig. 2 illustrates the type of bucket line used. Pins are 7⅛in. in diameter, of forged nickel-chrome steel, heat-treated. Each bucket, with lip, bushing, and pin, weighs 2¼ tons, and the bucket line 315 tons.

The lower tumbler, 5ft. 8in. in diameter, is a nickel-chrome steel casting, with manganese steel liners and weighs 20 tons. The twenty-nine sets of ladder rollers are of high-carbon chrome steel castings pressed on nickel-chrome steel heat-treated shafts.

The upper tumbler is of high-carbon chrome steel, cast integral with the shaft, and is provided with forged and heat-treated nickel-chrome steel heel plates and manganese ear plates. It is driven by the main driving gear, consisting of two large spur gears on the upper tumbler shaft, two pinions, and two herring-bone gears on an intermediate shaft, and two herring-bone pinions on the pulley shaft. The pulley shaft has an adjustable flange coupling between the two pinions to equalise the loading on each set of gears; also a brake on one end and a large pulley on the other, which is driven by the main drive belt from the ladder hoist winch.

Discharge from the buckets is received in the main hopper. Material dropped from the buckets and escaping the main hopper is caught by the save-all. It is classified by grizzly bars and passed into a sluice system which discharges into a well hole at the after end.

The main hopper discharges into a revolving screen, 9ft. in diameter and 50ft. 6in. long, the perforated length being slightly more than 37ft. The screen plates are of abrasion-resisting steel, perforated ¾in. to 1½in. and 1½in. to ¾in. The screen shells are of mild steel with manganese steel wearing bars.

The lining which discharges directly upon the stacker belt is constructed of nickel-chrome steel bars. This lining is 44in. wide and of seven-ply rubber furnished with a ribbed surface to prevent the sands from running backwards. The stacker ladder is 250ft. in length and is the longest ever constructed. It is supported with a three-point suspension of a new double type, and is swung from the stacker gantry at the stern. Two direct connected worm gear winches are used for hoisting and lowering. The motor that operates the stacker belt is equipped with ball bearings, and the belt is V-driven at its discharge end, and is fitted with a brake to prevent reversal under load.

The undersize screen discharge is divided between two

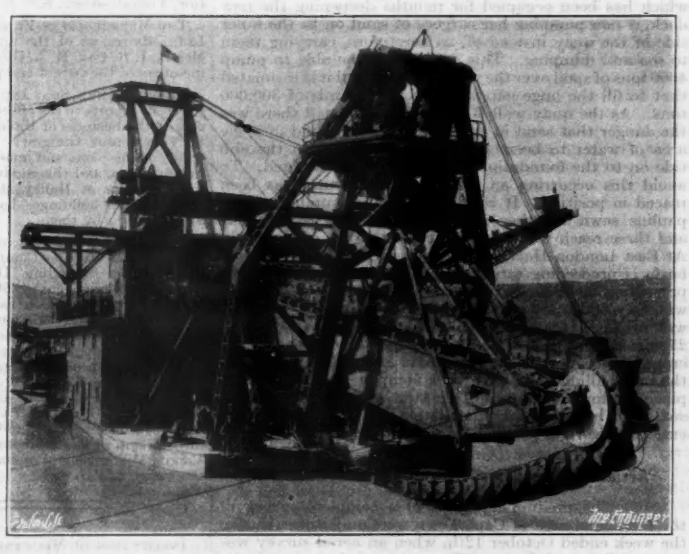


FIG. 2—BUCKET LINE OF GOLD DREDGER

double banks of table sluices, an upper and lower bank arranged in two sets on each side and below the revolving screen. Standard construction is used in connection with all sluices. The total area is 9000 square feet. The lower banks discharge into the pond through vertical sumps extending through the hull or by means of vertical deflectors into the boots of two bucket elevators, symmetrically placed on each side of the dredge, where the sand is picked up by the elevators, dewatered and discharged on to the stacker belt. This plan controls the sand accumulation in the pond. The upper bank of sluices discharges over the stern.

Regulating movements of the dredger are in accord with standard practice, and all control levers are concentrated in the dredge control room.

EQUIPMENT.

Pumps.—These comprise two 14in. centrifugals of the Yuba type, one for high pressure and the other for low-pressure service; one 6in. dual-service centrifugal for the hopper, save-all, and general use; one 4in. Yuba centrifugal for clean-up purposes; and one 10in. centrifugal monitor pump for use in tearing down the high bank necessarily carried in deep dredging. All pumps are directly connected to the motors. The 14in. spray pipe is connected at each end of the revolving screen to supply pipes. The suction inlets are all outboard and protected against floating rubbish.

Electrical Equipment.—The service is delivered to the dredger at 4400 volts to a heavy cable that can be attached to either one of the two junction boxes at the stern. These boxes supply to feeders, one of which extends to the monitor pump motors and the other to three 400-kVA transformers, which step down to 440 volts. The power factor conditions have been much improved by the installation of two 100-kVA capacitors on the main feeder to the bucket line and a further one of 100-kVA on the main feeder to the stern control room. No fuses are employed, but air and oil circuit breakers are used. Practically all the electrical apparatus is Westinghouse or General Electric, and includes push-button controls for most of the motors, and a bell-and-horn signalling system connecting the winch room with the main deck.

Motors and their Applications.

Main motor, 650 h.p., cooled by forced draught, ladder hoist and bucket line operation.
Swing winch motor, 75 h.p., silent chain drive.
Screen motor, 100 h.p., V-belt drive.
Stacker motor, 100 h.p., V-belt drive.
Sand bucket elevators, 5 h.p. each, geared motors.
High-pressure pump, 150 h.p., 0·8 synchronous motor.
Low-pressure pump, 100 h.p., 0·8 synchronous motor.
Dual pump, 75 h.p.
Clean-up pump, 15 h.p.
Main drive crane, 7·5 h.p.
Two bow cranes, 3 h.p. each.
Tool motor, 2 h.p.
Two 6in. vertical hull pumps, each 10 h.p., vertical motor.
Stacker hoist, 25 h.p., silent chain drive.
Stern Jitney winch, 3 h.p.
Monitor pump, 300 h.p., 4400 volts.

The total installed horse-power amounts to 1500, with a power factor of 94–96.

The Lighting System.—Two 1000-watt floodlights are placed upon the bow gantry and two 500-watt ones upon the bow housing. Smaller floodlights are placed at vantage points in addition.

The writer is indebted to Mr. C. M. Romanowitz for valuable assistance with regard to the technical details of the project.

Porosity in Weld Metal.*

THE ill effect of porosity in weld metal is not always realised. Concentration of stress takes place at the pores, and as a result the fatigue value of the metal is lowered.

The effect of local stress at the pores is evident at the surface of the weld metal, and the local shearing that takes place there is to be seen at the surface of tensile specimens.

The following tensile figures were shown by two specimens :—

Specimen	A	B
Description	Sound weld metal	Porous weld metal
Yield, tons per sq. inch	20·4	19·3
	18·9	19·7
Ultimate, tons per sq. in.	27·7	25·3
	27·3	25·8
Elongation, per cent.	26·3	34·5
	26·3	34·0
Reduction in area, per cent.	59·0	56·0
	59·0	55·0
Surface of fracture	Fibrous, cup and cone; Very porous	Fibrous, uneven break. A few pores only
	Ditto	Ditto

The elongation of all specimens was measured on a gauge length of 4 $\sqrt{A}$, and the greater elongation shown by the porous metal is very noticeable. This is due to local stretching at the gas holes, and the figures are therefore fictitious as a measure of ductility. For a similar reason porous all weld metal specimens of poor ductility are sometimes found to give a greater elongation on large gauge lengths than on small. The rating of ductility of weld metal by means of the elongation may therefore be a very false guide when the metal is porous and cause preference to be given to what actually is the inferior material.

An attempt was made to investigate the matter further by means of the two following simple experiments. The results were, however, disappointing. For the first, two similar tensile specimens were prepared from normalised mild steel, and one of them by aid of a tool made for the purpose had very fine marks stamped on the surface to imitate small gas holes. The figures obtained were as follows :—

Specimen	A	B
Description	Plain surface	Marked surface
Yield, tons per sq. in.	16·82	17·19
Ultimate, tons per sq. in	27·12	27·30
Elongation, per cent.	36·0	36·6
Reduction in area per cent.	60·9	58·8
Surface of fracture	Fibrous	Fibrous

The small differences in result are no greater than those due to experimental inaccuracy. As the imitation gas holes lay at the surface only, and not throughout the mass it was naturally not expected that any marked change would occur. It was hoped, however, that the figures would vary sufficiently for any tendency for a change to be observed.

As a next experiment bend strips were prepared of the normalised material, and the tension side of one set marked as before. Here, again, as the imitation gas holes did not occupy the full cross section of the material, the conditions did not strictly imitate those in a bend specimen of a

* From the Technical Report for the years 1933–34 of the British Engine Boiler and Electrical Insurance Company, Ltd.

weld. They, however, gave a more close representation, owing to the relatively high strain at the outer surface of a bend specimen, compared with the interior.

Specimen ..	A ..	B
Description	Plain surface ..	Marked surface
Width = 1 t. .	180 deg.; bent and flattened. No crack. Elongation = 72 per cent. ..	180 deg.; bent and flattened. Small crack. Elongation = 72 per cent.
Width = 5 t	180 deg.; bent and flattened. Very fine crack. Elongation = 70 per cent. ..	180 deg.; inside diameter about 1½ t. Cracks. Elongation = 60 per cent.

Both marked specimens developed cracks more readily than the plain specimens. From calculation, a sound specimen 1 t wide is expected to remain intact until an elongation of 144 per cent. is reached, whereas the B specimen showed cracks with an elongation of only 72 per cent. In comparison, porous butt welded specimens of low ductility, 1 t wide, have shown an elongation well up to the calculated figures. The elongation of 60 per cent. yielded by the B specimen, 5 t wide, though it was actually exceeded by the form A specimen, is equal to that calculated for sound metal.

Further results obtained during the current year tend to confirm a conclusion previously reached, that pores help to relieve the lateral stress in wide specimens, thus tending to an improvement on the calculated value and to counterbalance any tendency for the pores to promote premature fracture.

Conclusion.—To generalise is unwise as porosity varies, in degree, and occasional inclusions of irregular outline may behave very differently to a large number of small gas holes of smooth profile. In a tensile test the reduction in area is a safer guide to the ductility of porous weld metal than the elongation. On a bend test, with a specimen 1 t wide, porous weld metal, though it may sometimes lead to premature fracture, is very often found to behave as well as similar metal with the pores absent. With specimens 3 t or 5 t wide, porosity tends to reduce the severity of the test and make it equivalent to that obtained from a specimen 1 t wide.

South African Engineering Notes.

(By our South African Correspondent.)

CAPE TOWN, November 15th.

Huge Order by Railways.

THE South African Railways Administration has placed orders overseas for 950 drop-sided bogie trucks and 1000 four-wheel open type trucks at a cost of £950,000. These vehicles will be placed in traffic from April to June, 1936. In addition, the railway workshops in South Africa are busy erecting 3478 trucks of different types, as well as 181 tank cars for petrol, fuel oil, crude oil, liquid asphalt, &c. So busy are the shops that they are unable to cope with any more work of construction with the rapidity of output desired, which is the reason for placing such large orders overseas. In fact, a determined effort is being made by the Administration to cope with the soaring traffic which it is being called upon to handle all over the Union. The first tenders called for were for 450 bogie trucks and 500 short steel trucks, on July 9th; but the traffic grew so rapidly that on August 22nd further tenders for 500 bogie wagons and 500 short steel trucks were called for by cable. The order for the 950 trucks was placed with Metropolitan-Vickers. The second order was divided, the portion for 500 bogie wagons being placed with a Belgian firm, which sublet half the order to another Belgian firm, the total being increased to 500 (250 for each firm). A further order for 500 short steel trucks was placed in Germany, being divided between six firms, West Deutsche Koeln, with 110 trucks, having the largest share.

Locomotive Constructed in the Union.

The first locomotive to be designed and constructed—not merely erected—in South Africa has just been turned out at the Pretoria railway workshops. The engine is of the 2–10–2 type, designed to work on the very lightest rails in use on the railway system, but is of the same power as the big 15A class engines, which, until a few years ago, was the standard main line engine and is still used in main line work between Cape Town and De Aar. Although the wheels of the new engine are only 46in. in diameter, it reached a speed of 55 miles an hour on trial without being fully opened out. This locomotive has been designed for use in South-West Africa, where the old light section German rails are still in use. Owing to water scarcity it may be fitted eventually with a condensing tender. It will also replace the old 7th class locomotives on all light lines which have bridges strong enough to carry the engine. Mr. A. G. Watson, the assistant general manager and chief mechanical engineer of the South African Railways, is to be congratulated in succeeding in combining speed and power to an extent not thought possible for light rails.

Dumping Duty on Steel.

The Union Government has imposed a dumping duty on steel joists, channels, equal and unequal angles, rails and fish-plates, bars, flats, tees, galvanised and black sheets, casing and tubes from Belgium, Luxembourg, Germany, and France, of a class produced or manufactured in the Union. The Minister of Finance is satisfied that these goods have been and are being exported at a rate of freight lower than the rate prevailing at the time of shipment, and that detriment has resulted in consequence to the iron and steel manufacturing industry in the Union. Accordingly a freight dumping duty is imposed on these steel products from the countries mentioned above. The duty is equal to the difference between the net freight paid and that which would have been paid at the rate prevailing at the date of shipment. It is understood that this duty is the result of complaints to the Government by the South African Iron and Steel Works. British manufacturers should benefit somewhat, as they will be able to supply the coastal areas of the Union, as they can deliver in these areas from overseas cheaper than the Pretoria Steel Works, handicapped by the heavy railage over the distance of nearly 1000 miles from works to coastal areas can. At the same time, the British makers will have the aid of the dumping duty in their competition with Germany, Belgium, &c. At present large quantities of rails and fish-plates are coming from the Continent for the railways—nearly 20,000 tons of rails have come from there in the last month. Britain is also supplying, but a much smaller part of the order has gone there.

An Arsenal for the Union.

What will probably be the last South African overseas order for cartridges is about to be placed. The annual indent is being issued for 10,000,000 rounds of 0·303 Mark VII, which are intended to serve the needs of the Department of Defence till the end of 1936. Originally the Government had hoped to have the munitions plant being erected at Roberts Heights in production by now, but it has been found that the scheme takes far longer to reach fruition than had been thought. However, the difficulties have now been cleared away, and it is almost certain that within the next twelve months the first arsenal in the Union will be a reality, though it will operate on a much smaller scale than those overseas, of course. The Minister of Defence is taking measures to ensure an aeroplane force equal to that of most second-rank Powers. The scheme includes the enlisting of 1000 pilots and 2000 mechanics and there will be 250 aeroplanes. A few planes will be obtained as patterns and then the balance will be manufactured here under licence from the overseas makers. This arrangement will enable the Union to keep abreast of improvements in the design of aeroplanes, as pattern machines or parts will be obtained from overseas and manufactured here under licence. It is almost certain that neither of these undertakings can be justified upon economical grounds, but, of course, with the revenues of the gold mines capable of being taxed to any extent required to finance Government expenditure, the question of cost is an unimportant one for the present. The Minister of War's defence plans include the building up of a defence force of about 50,000 men in the next few years. The Union should then feel fairly secure, especially as she has no armed neighbours unless the Union's example is followed.

Union Harbour Extension.

The coastal towns of the Union, Durban and Cape Town in particular, are anxiously awaiting an announcement by the Minister of Railways and Harbours concerning the great scheme for harbour extension which has been promised. That there is urgent need for such an undertaking is apparent at the present time, when numerous ships are being diverted to the Cape route to avoid any war risks which might have to be run if the Suez Canal route was taken. These ships will tax the port facilities, both for berths and the provision of fuel oil and coal for the bunkers. In the meantime steady progress is being made at Cape Town in building the 900ft. quay for big ships, and the work of excavating a trench under water and laying the foundations of the quay is proceeding night and day. The work of filling up the gap between the quay wall and the rubble mole forming a knuckle to the northern side of the new basin has just been begun, and this will reclaim a big area upon which will be erected sheds and other buildings. The suction dredger "Oceanus," which has been occupied for months deepening the new dock, is now pumping her cargoes of sand on to the inner side of the quay instead of, as heretofore, carrying them to sea and dumping. This dredger will be able to pump 4000 tons of spoil over the wall each day, and it is estimated that to fill the huge gap will require upwards of 300,000 tons. As the quay wall is only half completed there was the danger that sand in suspension when poured into the area of water to be reclaimed would drift with the ebb tide on to the foundations that are being concreted. To avoid this occurring an ingenious contrivance has been placed in position. It consists of a large number of tarpaulins sewn together and weighted with 80-lb. rails, and these reach from the surface to the bed of the dock. At East London Harbour the construction of the turning basin is proceeding satisfactorily, whilst the provision of precooling facilities and the extension of the south breakwater by 600ft. are in hand. At Port Elizabeth the quay wall of No. 1 Quay has been completed over a distance of 2700ft. and at No. 1 berth the cargo shed, five electric cranes, three electric capstans, road and rail facilities, and the marshalling yard have been completed. Pending the placing before Parliament of the large scheme for providing sufficient berthing accommodation, &c., at Durban no extensive work is proceeding at that harbour.

Aerial Survey of Cape Town.

The preliminary steps of a complete survey of the municipal area of Cape Town were undertaken during the week ended October 12th, when an aerial survey was successfully carried out. The survey is being made by Mr. Norman Roberts, managing director of the African Air Survey Company, of Johannesburg, together with his pilot and photographer. A specially fitted plane was used and during the week practically the whole municipal area was photographed. Of the week about eight hours were occupied in flying and taking photographs. But this represents only the preliminary work in this survey. Altogether nearly 1000 photographs have been taken. It now remains for these pictures to be joined together to form a composite whole the mosaic air map. From this a line map is taken. It is estimated that one hour in the air taking photographs will provide three men in the drawing-office with sufficient work to keep them busy for a month.

The Kalahari Scheme.

Colonel Denys Reitz, Union Minister of Agriculture, was a member of an air reconnaissance party which flew over the Kalahari recently. According to Colonel Reitz and his party, there is no possibility of increasing the rainfall of the Union by carrying out the late Professor Schwarz's famous Kalahari scheme of harnessing the Okavango and Linyati rivers. There is a chance, however, of making the Okavango flow 100 miles further into the Kalahari than it does to-day to give the Bechuanaland Protectorate natives water for their cattle and perhaps a certain amount of irrigation. There is also the possibility of developing the huge swamps of the Okavango if the malaria and tsetse fly can be overcome. One thing Colonel Reitz is emphatic upon, and that is that Professor Schwarz's idea of draining the Okavango swamps into the Makarikari depression is wholly untenable. Many who knew Professor Schwarz's intellectual calibre, his scientific training, and the time and research he devoted to the problem are still unconvinced that his scheme is impracticable.

Water for Somerset West and De Aar.

The population of the rising town of Somerset West, some 20 miles from Cape Town, is increasing so rapidly that it has become necessary to undertake a new water scheme. At present the water supply comes from a flow which is fairly strong in winter, but in the summer months becomes weak, and it has already had to be supplemented by water sold by the Cape Town Municipality from the pipe conveying its Steenbras water to the city, which is expensive. The new scheme is designed to bring water from the Lourens River. It is proposed to build a low weir from the Lourens River with attendant intake and screening chamber. From there the water will be conveyed through a 10in. pipe to the existing service reservoir, a distance of 12,000ft. At the reservoir a float valve will be fitted on the outlet end of the pipe so that water will only be taken out to supply requirements over and above the present yield, also running into the reservoir, thus avoiding waste. A 9in. pipe will be substituted for the present 4in. main and will have a length of 11,000ft. to the town. Supply from Steenbras will be in reserve for emergency. A waterborne sewage scheme is also contemplated in the not distant future. De Aar, the important railway centre on the main line from Cape Town to the north, has decided to push on with its water scheme, which has been approved by the ratepayers of the town. The water will be brought from a number of wells at Burgerville, a distance of 21 miles. The estimated cost of the scheme is £58,000 and most of that sum will go towards the purchase of the pipes required.

New City Engineer for Cape Town.

The General Purposes Committee of the Cape Town City Council has recommended and the City Council has approved the appointment of Mr. W. S. Lunn, B.Sc., A.M. Inst. C.E., as City Engineer, in succession to the late Mr. T. P. Francis. Mr. Lunn was a member of the Cape Town City Engineer's department before the Great War and was connected with the drainage of the southern suburbs and the Steenbras water scheme. After the war, in which he served with distinction, he was appointed City Engineer at Bloemfontein, where he initiated and carried through big municipal undertakings. The commencing salary at Cape Town is £2000 a year, rising by annual increments to £2500.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MR. W. L. SCOTT, M. Inst. C.E., M.I. Struct. E., has started in practice as a consulting engineer at Artillery House, Artillery-row, Victoria-street, S.W.1.

THE METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., advises us of the appointment of three new directors, Messrs. I. R. Cox, H. L. Guy, and G. A. Juhlin, all of whom are members of the parent company's staff.

GEORGE COHEN, SONS AND CO., Ltd., London, call our attention to recent reports to the effect that Albion Motors, Ltd., had purchased the business of Halley Motors, Ltd., including the works at Yoker, near Glasgow. Messrs. Cohen inform us that the whole of the plant and machinery, stocks, vehicles in course of manufacture, and the goodwill of the business—in fact, all the former assets of Halley Motors, Ltd., with the exception of the land and buildings—have now been acquired from Albion Motors, Ltd., by them.

MR. F. S. HAYBURN, managing director of the Marconi International Marine Communication Company, Ltd., and of the Marconi Sounding Device Company, Ltd., has been appointed foreign envoy of the Marconi group of companies. Mr. Hayburn has been associated with the Marconi Marine Company for over thirty-one years, and has served both at home and abroad. His new appointment will take effect as from the end of this year, but Mr. Hayburn will continue to act as director of the Marconi Marine and Sounding Device Companies, and of the Norsk Marconikompani, and the Societe Anonyme Internationale de Telegraphie sans Fil, of Brussels. He will leave England for the East, on his first foreign mission, early in the New Year, and will be succeeded in the managing directorship of the Marconi Marine Company by Mr. H. R. C. Van de Velde, general manager of Marconi's Wireless Telegraph Company, Ltd.

INSTITUTION OF MECHANICAL ENGINEERS: NORTH-WESTERN BRANCH ANNUAL DINNER.—There was a good attendance at the annual dinner of the Institution of Mechanical Engineers, North-Western Branch, which was held on Thursday, December 5th, at the Engineers' Club, Manchester. All the speeches reflected the increased activity in various branches of engineering, and the brighter future it promises. The chair was taken by Mr. G. N. Shawcross, the Chairman of the Branch. In the unavoidable absence of Sir Josiah Stamp, Mr. B. Mount Jones, the Principal of the College of Technology, Manchester, proposed the toast of "The Institution of Mechanical Engineers" in a witty and able speech, congratulating the Institution on the activity of its various branches and its interest in research. The President of the Institution, Colonel A. E. Davidson, responded, and recalled the many services rendered to the Institution by its North-Western Branch members, both past and present. There was now, he said, a real need for designers and draughtsmen in many of the branches of the industry. Design, he pointed out, was of no less importance than was research work. In proposing the toast of "Our Guests," Mr. J. M. Newton referred to the work of pioneer engineers in the Manchester district. The Lord Mayor of Manchester, Alderman T. S. Williams, responded, and was supported by Mr. Alan E. L. Chorlton, a Past-President of the Institution. Mr. Chorlton made a bold plea for greater daring in engineering work, which had in the past, he said, always led to progress. The toast of "The Chairman" was proposed by Mr. L. W. Schuster, and Mr. Shawcross briefly replied.

Markets, Notes and News.

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer. A comprehensive list of the prices of materials mentioned below will be found on the next page.

Steel Trade Developments.

The meeting of the British Iron and Steel Federation at Harrogate at the end of last week was not followed by the expected increase in prices. A number of the steel makers feel strongly that they are entitled to raise their quotations in view of the increases in the price of scrap and other raw materials. It is reported, however, that the authorities have indicated that such a move would not be approved at the present moment. Matters concerning the new British Iron and Steel Corporation were also discussed, as well as the best methods of controlling the imports of Continental iron and steel. Immediately prior to the Harrogate meeting representatives of the Federation and the Cartel met in London, and it is reported that the British steel makers explained their position with regard to the control of imports. They favour a system of licensing, the purchase of all imports by the British Corporation; the re-sale of the material to existing Continental agencies in London and the supervision of its distribution by joint committees. Another meeting is to be held in January and in the meantime the Continental steel makers are to consider the British suggestions. Although proposals have been made that the Steel Corporation undertake the sale of tin-plates and sheets, it is not considered likely that these industries will abandon their own selling arrangements, which have been efficiently organised for some years. The sheet makers have no central selling organisation, but they have their Sheet Makers' Conference, which meets once a month to discuss the various problems of the trade. The tin-plate makers also have a number of closely allied trade bodies to deal with their difficulties, and the greater part of the industry sells through a central selling organisation which has been in existence for some years. The British Steel Export Association will be absorbed by the British Iron and Steel Corporation, and it is understood that the rule by which only orders of 200 tons and over have been handled no longer operates and that the Corporation will quote for miscellaneous business. This suggestion has, naturally, upset the merchants, who fear that their businesses will suffer through the new company going direct to their customers. It is not known yet whether the Iron and Steel Corporation will follow the example of some of the selling organisations of the Continental steel industries and establish branches in the more important foreign markets. This week the British sheet makers announced that sheets $\frac{1}{8}$in. down to 3 m/m. had been brought under control and would be quoted for export at £9 f.o.b.

The Pig Iron Market.

The pig iron market seems to be settling down into rather quieter conditions, which promise to last over the end of the year. Deliveries of practically all descriptions of pig iron excepting forge iron are upon the heavy scale which has characterised the market for a long period, but the volume of new business has dwindled and with a few exceptions consists of small orders. On the North-East Coast the demand for foundry iron is in excess of the supply; but there seems no indication of fresh furnaces being put into operation on this description. A furnace which is being started in this district by Gjers and Co., Ltd., will produce ferro-silicon. The quantities of foundry iron going to the Scottish light castings makers are satisfactory, and if more were available it is probable that they would be considerably increased. Most consumers seem willing to add to their forward purchases, but the ironmasters are fighting shy of accepting this business except in special circumstances. Reports that Midland iron is being used in Scotland as a substitute for Cleveland foundry appear to be treated with indifference by the local producers, but it seems probable that this is the case, since the price of Midland iron to Scottish consumers is about 1s. 3d. less than for Cleveland. In the Midlands rather busy conditions developed this week and a number of important contracts were placed for delivery up till June, 1936, and beyond in some cases. For the most part, however, consumers are well covered forward and are inclined to mark time. In this district users generally seem to be watching the pig iron market closely, as the tendency is for the price of coke to advance, and although it was only recently that pig iron quotations were raised, an increase in the costs of raw materials might be reflected in another upward movement. For that reason most users are prepared to buy as far forward as the producers will sell. In Scotland the demand has been principally for small lots, but there is a steady flow of specifications to the producing works and deliveries are satisfactory. Good supplies of English iron are reaching the light castings industries, but, nevertheless, the make of the Scottish blast-furnaces is going into production. In the Lancashire market the consuming industries are taking good quantities, the one exception being perhaps the textile machinery manufacturers. Business in hematite iron has been active and the manufacturers are showing a disposition to scrutinise orders. The general impression seems to be that a price advance in this market is due, and this naturally stimulates buying.

The North-East Coast and Yorkshire.

It is many years since the steel works on the North-East Coast were so busy as they are to-day. There seems to be scarcely any department which is not working under pressure to maintain deliveries against contracts. Heavy inquiries also continue to reach the works from consumers who would willingly book further ahead than the producers care to sell. The position in this respect is rather dangerous, since it is feared that some at least of the demand is of a speculative character and represents buying against a possible rise in prices rather than purchases against actual or potential requirements. For this reason the works are inclined to scrutinise the orders they receive. The demand for structural steel is particularly heavy. The constructional engineering departments are pressing for deliveries, and in some cases complaints are heard of works being unable to keep their delivery dates. The orders for ships which have been placed on the North-East Coast are now represented by a steady demand for all classes of shipbuilding steel, and as new orders are expected to be placed with the shipyards during the next few weeks it is probable that there will be no relaxation in activity in this department. The works producing railway material are also well employed, not only upon home account, but also upon orders for export which have been placed during the past few weeks. Business in semi-finished steel has not been affected by the arrival of some of the additional quantities ordered by the British Iron and Steel Federation from the Continent. The works on this coast producing this class of material are working full time and are apparently unable to keep pace with the demand. The sheet works have received a considerable tonnage of orders lately, but the demand for galvanised sheets for export still lags and most of the recent business transacted has been in various descriptions of black sheets. In Yorkshire the steel works are operating practically at capacity, and some of the Sheffield works continue to produce at a record rate. The market requirements of basic billets show no signs of slackening and a heavy tonnage is being turned out. Lately there has been a considerable volume of business transacted with the motor car manufacturers, and there seem good prospects that the demand from this quarter will continue to develop until the end of the year. The market for high-speed steel has not expanded at the same rate as some of the other departments, but lately there has been a tendency for the business to increase. On the other hand, the requirements of stainless and heat-resisting steels have probably never before been on so large a scale as at present.

The Midlands and South Wales.

Rarely have such busy conditions ruled in the Midland steel markets at this time of the year as now prevail. The usual rush to get material away from the works before the Christmas holidays is in evidence; but so persistent have been the efforts of customers over the whole of this quarter to obtain deliveries that the extra pressure is scarcely noticeable. The steel works are carrying a heavy tonnage of orders for structural steel, and if new business is slightly restricted there is evidence that the demand will recover its full strength when the Christmas holidays are over. The constructional engineers were seldom better employed, and although most of them have bought well forward there is still a certain amount of covering to be done. Most of the recent business has been for supplementary parcels, but a heavy tonnage of sections, joists, and plates is passing into consumption, and it is generally anticipated that the demand for this class of material will gather strength early in the New Year. Fears that the price of structural steel would be raised at the steel makers' meeting at Harrogate at the end of last week proved groundless, but the market believes that an advance will be made at a not distant date unless the authorities indicate that they are opposed to such a course. Business in bars and strip has been well maintained, and both the steel works and the re-rollers are behind hand in deliveries. The latter still complain of the difficulty of obtaining raw material, but the additional imports of Continental steel are not expected to be available in full until the end of the month. There is not much difference now between the prices quoted by the associated and unassociated makers of bars, and it is understood that a form of gentlemen's agreement exists between these two sections of the trade. The Association price for the home market is £8 12s. for bars in 4-ton lots, 1 ton of a size, less rebates of from 2s. 6d. to 5s. For reinforced concrete bars the associated and the independent works both quote £8, whilst export business is still done at £6 17s. 6d. to £7 f.o.b. For strip the official price remains unchanged at £9 7s. It is expected that fresh supplies of bars, which will be included in the quota, will be available for the market shortly at about £7 5s. There has been a good demand for colliery steel, and there are expectations of an increase in the present price of £8 5s. for light arches and £8 15s. for heavy sections. In South Wales the steel works are well employed and are making regular deliveries of tin-plate bars. The market for tin-plates, however, is restricted by the International Tin-plate Association agreement, and most of the business now reaching the works is from home users.

Current Business.

The firm of Joshua Bigwood and Son (1930), Ltd., engineers, of Tempest-street, Wolverhampton, have purchased the works of the Rees Roturbo Manufacturing Company, Ltd., pump manufacturers, of Wednesfield-road, Wolverhampton, and later will move to the newly acquired premises. Yarrow and Co., Ltd., of Scotstoun, have secured a contract for plant and buildings in connection with the Dalmarnock Power Station, the tender being £471,040. The London, Midland and Scottish Railway Company have announced that their works and rolling stock programme for 1936 will involve the expenditure of £8,500,000 on major replacements and improvements. The programme includes the provision of 133 locomotives, 111 locomotive boilers, 687 carriages, 9485 wagons, 900 containers, and three steamers. The programme is distinct from the works which will be carried out under the proposed Government guarantee loan. Harland and Wolff, Ltd., have received an order from the Belfast Harbour Commissioners for a twin-screw Diesel-electric tug and tender. The Quebec and Ontario Transportation Company, Ltd., of Montreal, have placed a contract with Swan, Hunter and Wigham Richardson, Ltd., Wallsend, for an all-welded vessel of 2087 tons gross. The Steel Company of Scotland is to put into commission a new open-hearth furnace at Hallside Works. After having been idle for eight years, two light plate rolling mills at Smith and McLean's Milnwood Works, Mossend, Lancs., are to resume operations. W. Pickersgill and Sons, Ltd., Sunderland, have obtained a contract from the Hebburn Steamship Company, Ltd., for a 9000-ton motor ship. The engines will be supplied by the North-Eastern Marine Engineering Company, Ltd., Wallsend. The Lambton Hetton and Joicey Collieries, Ltd., have placed an order for a complete "static" dry cleaning plant with Colliery Engineering, Ltd., of Sheffield. The Department of Overseas Trade announces that the following contracts are open for tender:—Bagdad District Water Board: 784 dry dial type water meters of various sizes (Bagdad, December 17th); South African Union Tenders and Supplies Board: cast iron pipes (Pretoria, January 10th); Railways and Harbours Administration: 20,000-gallon pressed steel tank, 20ft. by 20ft. by 8ft., with supporting structure (Johannesburg, January 6th); Argentine State Railways Administration: supply of machine tools (Buenos Aires, January 9th); Tehran, Kampsax Consortium: 100 small steel railway bridges, consisting of primary sections (Tehran, January 13th).

Copper and Tin.

Business in the electrolytic copper market has been rather uninteresting during the past week. In America the wave of buying which commenced at the end of October and lasted until the end of last month seems to have spent its force and most consumers appear content to watch the market for a time. In Europe the consuming industries in practically all countries are by no means well covered; but, nevertheless, buying has been of a hand-to-mouth character. On the other hand, merchants, who seem to regard the present price of electrolytic as rather cheap and to take a favourable view of the market, have bought substantial quantities, and this has kept the price at around £40. During November the sales in America are understood to have reached a total of 31,600 tons, including 19,400 tons for delivery in February and 8900 tons for March. Lately there seems to have been a certain amount of copper offered in the United States by second hands at 9c., although the official price is still held at 9½c. These cheap sales are not thought to indicate weakness in the American position, and the producers there are credited with the intention of raising the domestic price to 10c. Lately the export price has been gathering strength and a persistent advance in this quotation would help the Americans to increase their home quotation. Speculators appear to have taken fresh interest in the London standard market and there has been a fair amount of buying. It looks as though a bull account was being built up, and as a result the carrying rate has increased from 6s. 3d. to 8s. 9d. . . . Contrary to expectations, the position in the tin market has not materially changed, and the arrival of about 1500 tons of Banca tin has not afforded much relief to the prompt position. There has been a good demand from the Continent for prompt metal and this has helped to keep the position tight and to hold the backwardation at around £11. As it is rather unusual for the Continental demand to expand at this season of the year, it is not surprising that the suggestion is heard that this buying represents indirect purchases by Italy; but there is no actual proof of this. At the moment the bear account seems to have been covered, and for this reason some surprise is expressed that so heavy a backwardation continues to exist. The International Tin Committee which met at the Hague last week increased the tin quota 10 per cent. to 90 per cent. of the standard tonnage. The increase will apply to the first quarter of 1936. On this basis it is estimated that the total production of tin next year will be 185,785 tons.

Lead and Spelter.

At the beginning of this week prices in the lead market had a firm appearance, but the collapse in the silver price brought about a sharp decline. The producers are credited with the view that it would be unwise to allow prices in this market to advance too quickly and are selling freely when values show signs of rising above the £18 level. Although consumption remains at a satisfactory rate, buying for industrial purposes has been rather quieter than for some weeks. Business usually shrinks during the last week or two of the year and remains dull until the middle of January, so that the decline in this respect is only a normal movement. Deliveries against contracts, however, are said to be well above the average for the time of year. The rather stringent position as regards Empire lead is likely to be relieved during 1936 by an increase of 30,000 tons to 40,000 tons in the Australian production. This is the result of the higher values which have ruled for some months and which have enabled properties to be re-opened and ores to be treated which at the lower range of prices were considered unprofitable. The American statistics give the production of lead in October as 131,333 tons, compared with 119,793 tons in September. . . . It is some time since any development of interest occurred in the spelter market. The demand remains steady, but with no particular feature and prices for the most part have simply followed the movements in the lead market. Most of the consuming industries are well employed and the quantities being absorbed show a tendency to increase. The galvanising industry, however, does not seem to make much progress and, comparatively speaking, has provided only a limited outlet for the metal. There have been some arrivals of Continental spelter this week, with the result that the contango has been kept firm at 6s. 3d.

Current Prices for Metals and Fuels.

Makers' official home trade prices per ton, delivered buyers' stations. Sections, joists and plates are subject to a rebate to home users purchasing only from associated British Steelmakers: joists, 22s. 6d.; plates and sections, 15s. Export orders of 250 tons and over may be subject to special quotations.

PIG IRON.

	Home.	Export.
	(*D/d Teesside Area*)	
N.E. COAST—	£ s. d.	£ s. d.
Hematite Mixed Nos.	3 10 6	3 2 0
No. 1	3 11 0	3 3 6
Cleveland—	(*D/d Teesside Area*)	
No. 1	3 12 6	3 4 0
No. 3 G.M.B.	3 10 0	3 1 6
No. 4 Forge	3 9 0	3 0 6
Basic (*Less 5/– rebate*)	3 10 0	—
MIDLANDS—		
Staffs.—	(*Delivered to Black Country Station*)	
North Staffs. Foundry	3 15 0	—
„ „ Forge	3 10 0	—
Basic (*Less 5/– rebate*)	3 15 0	—
Northampton—		
Foundry No. 3	3 12 6	—
Forge	3 7 6	—
Derbyshire—		
No. 3 Foundry	3 15 0	—
Forge	3 10 0	—
SCOTLAND—		
Hematite, f.o.t. furnaces	3 13 6	—
No. 1 Foundry, ditto	3 16 6	—
No. 3 Foundry, ditto	3 14 0	—
Basic, d/d (*Less 5/– rebate*)	3 10 0	—
N.W. COAST— Hematite Mixed Nos.	3 14 0 d/d Glasgow, 3 18 6 „ Sheffield, 4 4 6 „ Birmingham	

MANUFACTURED IRON.

	Home.	Export.
LANCS.—	£ s. d.	£ s. d.
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
S. YORKS.—		
Crown Bars	9 12 6	—
Best Bars	10 2 6	—
MIDLANDS—		
Crown Bars	9 15 0	—
Marked Bars (Staffs.)	12 0 0	—
No. 3 quality	7 17 6	—
No. 4 „	8 10 0	—
SCOTLAND—		
Crown Bars	9 12 6	9 5 0
Best	10 2 6	9 15 0
N.E. COAST—		
Common Bars	9 12 6	8 15 0
Best Bars	10 2 6	9 15 0
Double Best Bars	10 12 6	10 0 0

STEEL.

LONDON AND THE SOUTH—	Home. £ s. d.	Export. £ s. d.
Angles	8 10 0	7 10 0
Tees	9 10 0	8 10 0
Joists	8 17 6	7 10 0
Channels	8 15 6	7 15 0
Rounds, 3in. and up	9 10 0	8 10 0
„ under 3in.	8 14 6	7 0 0
Flats, 5in. and under	8 14 6	7 0 0
Plates, ¼in. (basis)	9 0 0	7 15 0
„ ⅜in.	9 5 0	8 0 0
„ ½in.	9 10 0	8 5 0
„ ⅝in.	9 15 0	8 10 0
„ ¾in.	9 10 0	8 5 0
NORTH-EAST COAST—	£ s. d.	£ s. d.
Angles	8 7 6	7 10 0
Tees	9 7 6	8 10 0
Joists	8 15 0	7 10 0
Channels	8 12 6	7 15 0
Rounds, 3in. and up	9 7 6	8 10 0
„ under 3in.	8 12 0	7 10 0
Plates, ¼in.	8 15 0	7 15 0
„ ⅜in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ ⅝in.	9 10 0	8 10 0
„ ¾in.	9 5 0	8 5 0
Boiler Plates, ¾in.	9 5 0	—
MIDLANDS, AND LEEDS AND DISTRICT—	£ s. d.	£ s. d.
Angles	8 7 6	7 10 0
Tees	9 7 6	8 10 0
Joists	8 15 0	7 10 0
Channels	8 12 6	7 15 0
Rounds, 3in. and up	9 7 6	8 10 0
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ ⅜in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ ⅝in.	9 12 6	8 10 0
„ ¾in.	9 10 0	8 5 0
Boiler Plates, ¾in.	9 7 6	7 15 0

STEEL (*continued*).

GLASGOW AND DISTRICT—	Home. £ s. d.	Export. £ s. d.
Angles	8 7 6	7 10 0
Tees	9 7 6	8 10 0
Joists	8 15 0	7 10 0
Channels	8 12 6	7 15 0
Rounds, 3in. and up	9 7 6	8 10 0
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 15 0	7 15 0
„ ⅜in.	9 0 0	8 0 0
„ ½in.	9 5 0	8 5 0
„ ⅝in.	9 10 0	8 10 0
„ ¾in.	9 5 0	8 5 0
Boiler plates	9 5 0	—
SOUTH WALES AREA—	£ s. d.	£ s. d.
Angles	8 7 6	7 10 0
Tees	9 7 6	8 10 0
Joists	8 15 0	7 10 0
Channels	8 12 6	7 15 0
Rounds, 3in. and up	9 7 6	8 10 0
„ under 3in.	8 12 0	7 10 0
Flats, 5in. and under	8 12 0	8 17 6
Plates, ¼in. (basis)	8 17 6	7 15 0
„ ⅜in.	9 2 6	8 0 0
„ ½in.	9 7 6	8 5 0
„ ⅝in.	9 12 6	8 10 0
„ ¾in.	9 10 0	8 5 0

IRELAND—	BELFAST. £ s. d.	REST OF IRELAND. £ s. d.
Angles	8 12 6	8 15 0
Tees	9 12 6	9 15 0
Joists	9 0 0	9 2 6
Channels	8 17 6	9 0 0
Rounds, 3in. and up	9 12 6	9 15 0
„ under 3in.	9 2 0	9 4 6
Plates, ¼in. (basis)	9 0 0	9 2 6
„ ⅜in.	9 5 0	9 7 6
„ ½in.	9 10 0	9 12 6
„ ⅝in.	9 15 0	9 17 6
„ ¾in.	9 12 6	9 15 0

OTHER STEEL MATERIALS.

	Home. £ s. d.	Export. £ s. d.
Sheets.		
10-G. to 13-G., f.o.r.	9 15 0	9 0 0
14-G. to 20-G., d/d	11 0 0	9 5 0
21-G. to 24-G., d/d	11 5 0	9 10 0
25-G. to 27-G., d/d	11 17 6	10 2 6

The above home trade prices are for 4-ton lots and over; 2-ton to 4-ton lots 10s. per ton extra; and under 2-ton lots, 30s. per ton extra.

Galvanised Corrugated Sheets, Basis 24-G.

Home.	£ s. d.
4-ton lots and up	13 5 0
2-ton to 4-ton lots	13 12 6
Under 2 tons	15 5 0

Export: £12 15s. 0d., c.i.f. India.
„ £11 10s. 0d., f.o.b. other markets.
„ Scandinavian Markets free.

Tin-plates.
20 by 14 basis, f.o.b. Bristol Channel Ports, 18s. 9d.
Tin-plate Bars, d/d South Wales Works, £5 10s. 0d.

Billets.	£ s. d.
Basic (0·33% to 0·41% C.)	6 12 6
„ Medium (0·42% to 0·60% C.)	7 2 6
„ Hard (0·61% to 0·85% C.)	7 12 6
„ „ (0·86% to 0·99% C.)	8 2 6
„ „ (1% C. and up)	8 12 6
Soft (up to 0·25% C.), 500 tons and up	5 10 0
100 to 250 tons	5 17 6
Rails, Heavy, 500-ton lots, f.o.t.	8 10 0
„ Light, f.o.t.	7 10 0

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	3/3 per lb.	
Ferro Tungsten	3/– per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£21 15 0	7.–
„ „ 6 p.c. to 8 p.c.	£21 0 0	7/–
„ „ 8 p.c. to 10 p.c.	£21 0 0	7/–
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£33 10 0	11/–
„ „ „ 1 p.c. carbon	£36 5 0	11/–
„ „ „ 0·50 p.c. carbon	£37 5 0	12/–
„ „ „ carbon free	9½ per lb.	
Metallic Chromium	2/5 per lb.	
Ferro Manganese (loose), 76 p.c.	£10 15 0 home	
„ Silicon, 45 p.c. to 50 p.c.	£12 15 0 scale 5/– p.u.	
„ „ 75 p.c.	£17 17 6 scale 6/– p.u.	
„ Vanadium	12/8 per lb.	
„ Molybdenum	4/6 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£200 to £205	
Cobalt	5/6 per lb.	

NON-FERROUS METALS.

Official Prices, December 11th.

COPPER—		
Cash	£35 2 6 to £35 3 9	
Three months	£35 10 0 to £35 12 6	
Electrolytic	£39 5 0 to £39 15 0	
Best Selected Ingots, d/d Birmingham	£40 0 0	
Sheets, Hot Rolled	£66 0 0	
	Home.	Export.
Tubes, Solid Drawn (basis)	10½d.	10½d.
„ Brazed (basis)	10½d.	10½d.
BRASS—		
Ingots, 70/30, d/d Birmingham	£32 0 0 to £33 0 0	
	Home.	Export.
Tubes, Solid Drawn, 2/1 Alloy	9¾d.	9¾d.
„ Brazed	11¾d.	11¾d.
TIN—		
Cash	£219 0 0 to £219 10 0	
Three months	£208 5 0 to £208 10 0	
LEAD	£16 17 6 to £16 18 9	
SPELTER	£15 2 6 to £15 7 6	
Aluminium Ingots (British)	£100	

FUELS.

SCOTLAND.

LANARKSHIRE—	Export.
(f.o.b. Grangemouth)—Navigation Unscreened	14/– to 14/6
Hamilton Ell	16/6 to 17/–
Navigation Splints	18/– to 18/6
AYRSHIRE—	
(f.o.b. Ports)—Steam	14/6 to 15/–
FIFESHIRE—	
(f.o.b. Methil or Burntisland)—	
Prime Steam	16/–
Unscreened Navigation	15/6 to 16/–
LOTHIANS—	
(f.o.b. Leith)—Hartley Prime	16/– to 16/6
Secondary Steam	15/6 to 16/–

ENGLAND.

YORKSHIRE, MANCHESTER—	
B.S.Y. Hard Steams	18/6 to 21/6
Furnace Coke	14/6 to 17/6
NORTHUMBERLAND, NEWCASTLE—	
Blyth Best	15/6
„ Second	14/6 to 15/–
„ Best Small	10/6 to 11/–
Unscreened	12/6 to 14/–
DURHAM—	
Best Gas	14/8
Foundry Coke	19/– to 20/–

SHEFFIELD—	Inland.
Best Hand-picked Branch	24/– to 26/–
South Yorkshire Best	21/– to 23/–
South Yorkshire Seconds	18/– to 19/–
Rough Slacks	9/– to 10/–
Nutty Slacks	8/– to 9/–

SOUTH WALES.

CARDIFF—	
Steam Coals:	
Best Admiralty Large	19/6
Best Seconds	19/– to 19/4½
Best Dry Large	18/9 to 19/3
Ordinaries	18/3 to 18/6
Bunker Smalls	12/6 to 13/6
Cargo Smalls	11/6 to 12/6
Dry Nuts	22/– to 27/6
Foundry Coke	27/– to 40/–
Furnace Coke	19/– to 22/6
Patent Fuel	21/–
SWANSEA—	
Anthracite Coals:	
Best Large	36/– to 40/–
Machine-made Cobbles	41/– to 48/6
Nuts	40/– to 48/6
Beans	25/– to 30/–
Peas	19/– to 23/–
Rubbly Culm	11/– to 11/6
Steam Coals:	
Large Ordinary	18/– to 20/6

FUEL OIL.

Inland consumption; contracts in bulk.
Exclusive of Government tax of 1d. per gallon.

Ex Ocean Installation.	Per Gallon.
Furnace Oil (0·950 gravity)	3½d.
Diesel Oil	4d.

French Engineering Notes.

(From our own Correspondent in Paris.)

The Navy.

THE Naval Estimates to be presented to the Chamber of Deputies provide for an expenditure in 1936 of 1547 million francs, an increase of 334 millions on the total for the present year. For the shipbuilding programme the expenditure is not definitely stated, because it will be necessary to utilise additional credits already granted and possibly new funds in order to make up for arrears. The object of the Ministry of the Marine is to carry on the work as rapidly as possible. Next year the "Dunkerque" will be completed, as well as four cruisers, seven convoys, and two submarines. Work on the first 35,000-ton battleship has been begun in the Salou dock at Brest vacated by the "Dunkerque," and on account of its length of 242 m. it will only be possible to build 200 m. of the hull, which will be completed outside in the same way as was done to the 25,000-ton battleship. Work on the second big battleship will begin on January 1st, 1937, the day after the expiration of the Washington Treaty, and for the sake of economy, as well as rapidity of execution, much of the material ordered for the first battleship is being duplicated. The second battleship will certainly be built in the new 300 m. construction dock at Saint-Nazaire, if it can be completed in time. It is announced that the old battleships will be replaced as soon as possible. The significance of this activity lies in the fact that the French have gone to the London Naval Conference with an unalterable programme of two 25,000 and two 35,000-ton battleships, so that the limit of individual tonnage cannot be reduced below the latter figure, at least for a number of years. This launching out into big battleships was, of course, the consequence of Italian initiative. For greater protection from hostile aircraft in the Western Mediterranean works are being carried out for a naval base at Mers-el-Kebir, near Oran in Algeria.

Flood Protection.

During the period of serious floods in the Rhône area below Lyons and in the south-western regions watered by rivers taking their rise in the Massif Central, it was noteworthy that there was no danger of the Seine overflowing its banks. The present increase in the volume of water would have caused serious misgiving in times past, and it is now clear that the works undertaken as a protection against floods have, at least, greatly attenuated the risk. The most effective of these works are the removal of obstructions in Paris, the replacing of old barrages by others that can be opened in times of flood, and the dredging of the river and removal of small islands below the city, whereby the river has been given a freer course to the sea. What effect the creation of flood reservoirs in the Haute-Marne will have on the Seine level is uncertain, but the two smallest reservoirs are now in operation and their inauguration coincides with an improvement in the general conditions which tends to give confidence in their efficacy. The disastrous floods in the south, which, periodically, cause enormous and irreparable loss, are partly attributed to deforestation of the Massif Central, and an organised plan of afforestation is now being undertaken in that elevated range, as well as in other parts of the country; but whatever results may be achieved by the reconstitution of forests it is recognised that rivers must be allowed free passage to the sea. The works for improving navigation on the Rhône, when completed many years hence, may remove the danger of periodical flooding of the country through which it flows.

Colonial Works.

At their last meeting, the Association des Grands Ports Français passed resolutions urging the Government to carry out without delay the proposals of the Colonial Economic Conference for the equipment of colonial ports. As the programme of colonial development is held up by the national economy cuts which have eliminated new expenditure, and little can be done until financial stability is restored, the Association asks the State to grant concessions for the equipment of ports wherever such work is necessary. At present the work is undertaken by the State, represented by the colonial administrations, and it is suggested that if recourse were had to private enterprise there would be no difficulty in financing operations and carrying them out rapidly. The great industrial groups can usually command all the money they need. The Association also passed a resolution in favour of reforms in the economic status of Protectorates which have for a long time been insisted upon, notably by the Marseilles Chamber of Commerce, which urged the Government to abrogate the Treaty of Algeciras providing a free market for international trade in Morocco. If this attempt to make the French Empire one economic unit to include the Protectorates, in which foreigners have the same rights to trade as the French, were carried into effect, a complicated situation would arise, especially at a time when there are proposals abroad to open colonies to international enterprise.

Marcel Deprez Celebration.

The fiftieth anniversary of the first practical result obtained by the distinguished engineer and professor, Marcel Deprez, with long-distance transmission of electrical energy, was celebrated last week at the Conservatoire des Arts et Métiers in the presence of the President of the Republic, Monsieur Albert Lebrun, who is himself an engineer and a former student at the Ecole Polytechnique. The first communication by Professor Deprez on this subject was made to the Académie des Sciences in 1880, and two years later he showed the possibility of long-distance transmission by installing a line some miles in length which he arranged on grounds available for the demonstration at Munich. That was the epoch of direct current, and the problem was not solved economically until just fifty years ago, when Lucien Gaulard showed that alternating current could be stepped up with transformers. The name of Lucien Gaulard was associated with that of Professor Marcel Deprez in the celebration organised by the Société Française des Electriciens.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

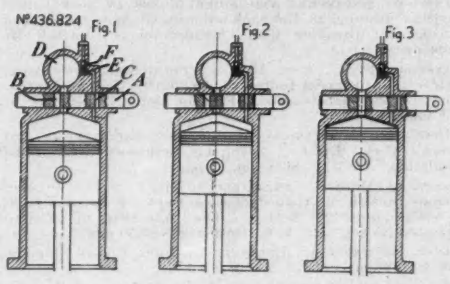
Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

436,824. October 18th, 1934.—FUEL-FEEDING ARRANGEMENTS FOR INTERNAL COMBUSTION ENGINES, M. J. A. de Malvin de Montazet, 163, rue Blomet, Paris, France, and I. Johanson, 23, Boulevard Gallieni, Argenteuil (Seine et Oise), France.

This is a two-stroke cycle engine. In the cylinder head there is a slide valve A provided with two ports B and C, of which B communicates directly with the combustion chamber D, and C

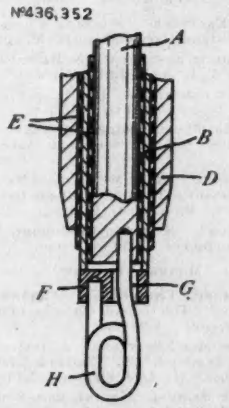


through the atomiser E. The fuel is injected through the ball non-return valve F. In the position of the slide valve shown in Fig. 1 the piston is rising and compressing the contained air. As shown in Fig. 2, the compressed air rushes through the port C and the atomiser E into the combustion chamber D and is ignited. The valve then moves to open the port B—see Fig. 3—and the explosion acts on the piston to effect the working stroke.—*October 18th, 1935.*

ELECTRICAL APPLIANCES.

436,352. March 21st, 1935.—INCANDESCENT WIRE IGNITION PLUGS, Robert Bosch Aktiengesellschaft, 4, Militärstrasse, Stuttgart, Germany.

This invention relates to incandescent ignition plugs for heavy-oil engines, which will be of small dimensions and yet be robust in construction to withstand operative strains. A is a central electrode, B a sleeve-shaped outer electrode, and D the plug

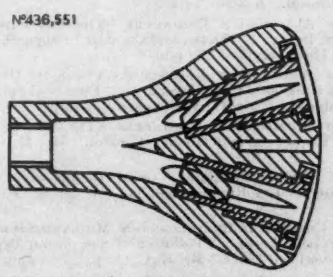


body of an incandescent wire ignition plug. These parts are insulated from each other by insulating layers E. The outer electrode projects beyond the central electrode. A disc F is secured to this projecting end, and has a hole G excentric to the axis of the plug, through which hole the end of the ignition wire H of the plug secured to the central electrode passes. The other end of the ignition wire is let into the disc and secured therein.—*October 9th, 1935.*

FURNACES.

436,551. April 18th, 1934.—PROMOTING COMBUSTION IN FURNACES, G. Bachler and Rotationsfeuerungspatentgesellschaft m.b.H., 14, Herrengasse, Vienna I., Austria.

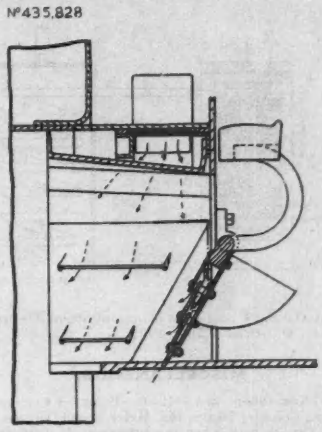
The inventor complains that generally combustion is more intense towards the middle of a grate than at the sides, and that



as a consequence clinkers are formed. So he injects air, steam, or gas through a special nozzle. No particular pressure of injection is mentioned. The nozzles, as will be seen from the drawing, have helical passages, which have preferably a pitch of 12 deg. The issuing jet is said to spread the heat of the fire across the grate.—*October 14th, 1935.*

435,828. July 14th, 1934.—FURNACE DOORS, A. W. Bennis, Little Hulton, near Bolton, Lancs.

This is an arrangement for keeping the furnace door of a boiler cool. The door is built up of a single front plate and a series of inside baffle plates, arranged much as the slates on a roof, but with narrow openings between each layer. Air is admitted to the intervening space from the sides of the door

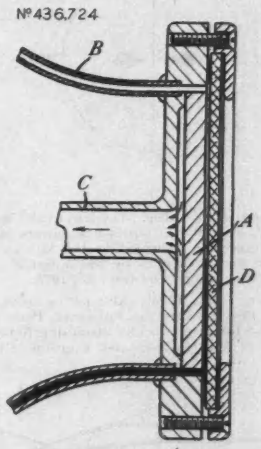


from a forced draught supply, and escapes into the furnace. Cheek plates attached to the sides of the door close the air passages when the door is opened.—*September 30th, 1935.*

TRANSFORMERS AND CONVERTERS.

436,724. April 13th, 1934.—VAPOUR ELECTRIC CONVERTERS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2, and E. Gallizia, of The General Electric Company, Ltd., Engineering Works, Witton, Birmingham.

This invention relates to vapour electric converters of the kind arranged to be pumped while in service, and is concerned with means for automatically controlling the pressure inside the converter vessel. It is known that mercury vapour converters, if caused to carry a relatively heavy load when cold, tend to become unstable owing to the low vapour pressure inside the converter vessel, such instability manifesting itself in the form of severe voltage surges across parts of the transformer windings, and the object of the invention is the provision of

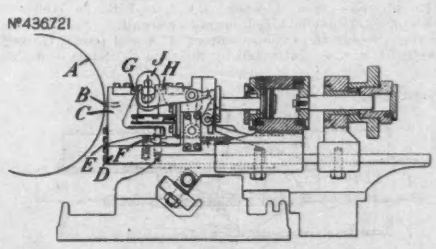


improved means for overcoming this difficulty. A vapour electric converter accordingly is provided with a leak device, operation of which is automatically controlled in dependence on the temperature of the converter, or on a state or characteristic that varies with the temperature of the converter, and which is adapted to prevent too low a pressure in the vacuum chamber during operation of the converter when the temperature is low. The device takes the form of a porous diaphragm A through which the leakage gas can pass from the supply pipe B to the converter by way of the branch C. It is arranged behind a glass window D. Between the glass and the diaphragm there is a space which is filled with mercury when the converter is hot, but empties and allows gas to pass when it is cold. The film of mercury is shown at approximately half-glass high in the illustration.—*October 14th, 1935.*

MACHINE TOOLS AND SHOP APPLIANCES.

436,721. April 11th, 1934.—HYDRAULIC FEEDS FOR MACHINE TOOLS, A. Drummond, Ryde's Hill, Guildford, Surrey.

This feed gear is intended for very fine grinding—up to one ten-thousandth of an inch. Against the workpiece A there is pressed a hardened point B supported in a block C. This block is attached to the slide D by the spring plate E, and is



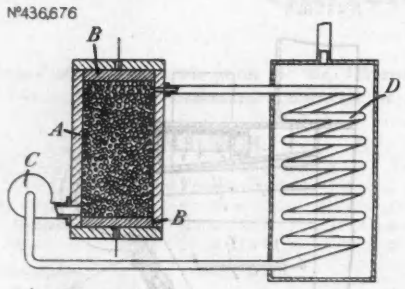
supported by the spring F. On the block C there is a jaw G and on the slide a jaw H. Between them they support a roll J. As the work is reduced in diameter the jaws gradually move apart until the roll falls between them, when it operates an electrical contact to stop the feed.—*October 11th, 1932.*

LIGHTING AND HEATING.

436,676. June 29th, 1934.—ELECTRICAL APPARATUS FOR HEATING FLUIDS, G. H. C. Roux, 103, rue Saint-Lazare, Paris, France.

For the purpose of heating gases the inventor uses a chamber A fitted with electrodes B B and filled with granular magnetite.

That material is chosen on account of its high resistance—from 1000 to 10,000 ohms per cubic centimetre—so that high voltages may be employed. He then pumps the gas through the heated

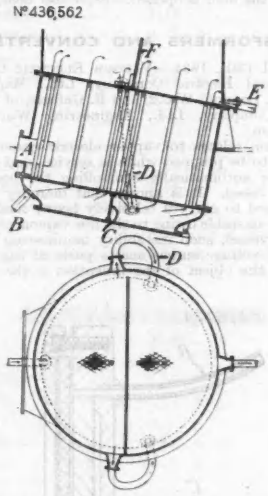


material by the fan C and uses it for any desired purpose, such as in the coil D.—*October 16th*, 1935.

MISCELLANEOUS.

436,562. November 3rd, 1934.—BULK EVAPORATORS, C. McNeil, Colonial Ironworks, Helen-street, Govan, Glasgow.

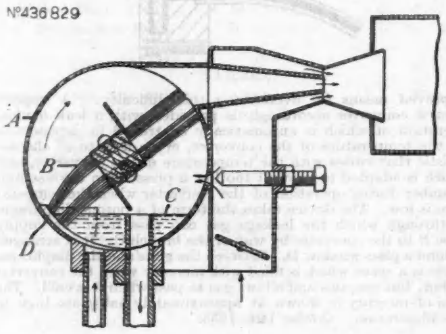
In this evaporator the heating tubes are set at an inclination, as shown in the drawing, and are heated by steam admitted at A. The liquid under treatment is admitted to the tubes at B and



flows upwards through the tubes. The lower tube box is divided by a partition C, so that the liquid first enters only one-half of the tubes. It is then returned to the box by the downcomers D D, and finally escapes by the outlet E. The baffle F prevents short circuiting.—*October 14th*, 1935.

436,829. January 5th, 1935.—APPARATUS FOR ATOMISING LIQUIDS, L. Peyeru, 3 rue des Favorites, Paris, France.

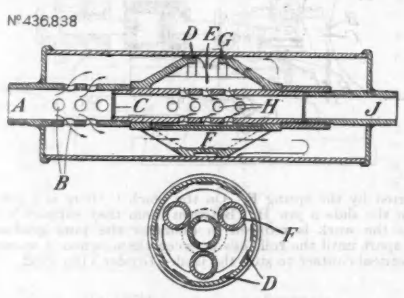
This is a device for mechanically atomising liquid fuels. In a circular chamber A there is rotated a group of thin flexible



steel plates B, which is described in the specification as a comb. These plates dip into the bath C of fuel and then encounter the cam plate D. As the plates pass over the end of this cam they rattle together and atomise the fuel they have picked up by capillary attraction.—*October 18th*, 1935.

436,838. February 28th, 1935.—EXHAUST SILENCERS, The Climax Rock Drill and Engineering Company, Ltd., 4, Broad-street-place, London, E.C.2, and R. de Helle St. Stephens, Homefield, Camborne, Cornwall.

In this silencer the exhaust enters at A and passes through the holes B, as it is obstructed by the plug C. Some of it then



passes through the notches D into the cavity E. The remainder passes through the passages F and, doubling back, goes through the notches G into the same cavity. The consequence is that the two streams of gas are opposed to one another and mingling escape through the holes H and pipe J.—*October 18th*, 1935.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

BELFAST ASSOC. OF ENGINEERS.—Queen's Hotel, Belfast. Smoking concert. 8 p.m.

INST. OF BRITISH FOUNDRYMEN: LANCASHIRE JUNIOR SECTION.—College of Technology, Manchester. Joint paper by Messrs. H. V. Grundy and A. Phillips. 7.30 p.m.

INST. OF ELECTRICAL ENGINEERS: LONDON STUDENTS.—Savoy-place, W.C.2. "The Students'" Lecture, "Developments in the Materials of Construction of Electrical Plant and Apparatus—Magnetic, Insulating, Conducting, and Mechanical," Mr. A. P. M. Fleming. 6.30 for 7 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Students' meeting, 39, Elmbank-crescent, Glasgow, C.2. "Ship Salving and Breaking with Classification of Metals," Mr. Mackenzie. 8 p.m.

INST. OF FUEL: EAST MIDLAND SECTION.—Joint meeting with Soc. of Chemical Industry. University College, Nottingham. "Compressed Gas as a Fuel for Motor Transport," Mr. R. Cook. 7 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, S.W.1. "Damping Influences in Torsional Oscillation," Dr. J. F. Shannon. 6 p.m.

INST. OF METALS: SHEFFIELD LOCAL SECTION.—In Non-Ferrous Section of Applied Science Dept. of University, St. George's-square, Sheffield. "The Adhesion of Electro-deposited Nickel," Mr. A. W. Hothersall. 7.30 p.m.

INST. OF SANITARY ENGINEERS.—Hotel Russell, London, W.C.1. Annual dinner. 7.15 p.m.

JUNIOR INST. OF ENGINEERS.—At Royal Soc. of Arts, John-street, W.C.2. Presidential address, "Coal, Power and Smoke," Sir Frank E. Smith. 7.30 p.m.

KEIGHLEY ASSOC. OF ENGINEERS.—At Messrs. Prince Smith and Stells' Canteen, Bradford-road, Keighley. "Sydney Harbour Bridge," Mr. J. Walton. 7.30 p.m.

N. EAST COAST INST. OF ENGINEERS AND SHIPBUILDERS.—Mining Inst., Newcastle-upon-Tyne. "Notes on the Development of Tugboat Machinery during the Past Forty-six Years," Mr. G. Baird. 6 p.m.

SOC. OF CHEMICAL INDUSTRY: PLASTICS GROUP.—Armstrong College, Newcastle-upon-Tyne. Dr. A. Caress. 7.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INST.—Royal Technical College, George-street, Glasgow. "Corrosion Problems in Chemical Industry," Mr. James Golder. 7.15 p.m.

TO-DAY AND SATURDAY, DEC. 14TH.

BOROUGH POLYTECHNIC.—Borough-road, S.E.1. Exhibition of Students' Work. Friday, 6 to 9 p.m.; Saturday, 4 to 9.30 p.m.

SATURDAY, DEC. 14TH.

INST. OF CIVIL ENGINEERS.—Students' afternoon visit to the Road Research Station, Harmondsworth, Middlesex.

INST. OF ELECTRICAL ENGINEERS: N. MIDLANDS STUDENTS.—Visit to works of W. L. Ingle, Ltd., Churwell. 2.40 p.m.

INST. OF MARINE ENGINEERS: JUNIOR SECTION.—85–88, The Minories, E.C.3. Dance. 7.30 to 11.15 p.m.

MANCHESTER ASSOC. OF ENGINEERS.—At College of Technology, Manchester. Conversazione and dance. 6.45 p.m. to 11.30 p.m.

NORTH OF ENGLAND INST. OF MINING AND MECHANICAL ENGINEERS.—Newcastle-upon-Tyne. "William Hutton's Observations on Coal, 1933," Professor G. Hickling. 2.30 p.m.

"THE OLD N'IONS."—Criterion Restaurant, Piccadilly, W.1. Fourteenth annual dinner. 7.30 for 8 p.m.

MONDAY, DEC. 16TH.

INST. OF AUTOMOBILE ENGINEERS.—At James Watt Memorial Inst., Birmingham. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7.30 p.m.

INST. OF AUTOMOBILE ENGINEERS.—At Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. "Small Car Engines," Mr. L. J. Shorter. 7.45 p.m.

INST. OF MECHANICAL ENGINEERS.—Storey's-gate, St. James's Park, S.W.1. Graduates' Meeting. "Oil," Mr. R. A. Robbins. 6.45 p.m.

INST. OF METALS: SCOTTISH LOCAL SECTION.—At Inst. of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. "Addition of Non-ferrous Metals to Cast Iron," Mr. J. E. Hurst. 7.30 p.m.

ROYAL AERONAUTICAL SOC.—At Inst. of Electrical Engineers, Savoy-place, W.C.2. "Wireless and its Application to Commercial Aviation," Capt. J. M. Furnival. 6 p.m.

TUESDAY, DEC. 17TH.

ANNUAL CHEMICAL DINNER.—Wharncliffe Rooms, Great Central Hotel, Marylebone, N.W.1. Dinner, 7.30 p.m.; dancing, 9.30 to midnight. Tickets may be obtained from Mr. F. A. Greene, The Chemical Club, 2, Whitehall-court, S.W.1.

ILLUMINATING ENGINEERING SOC.—Joint meeting with Royal Photographic Soc., 35, Russell-square, London, W.C.1. "Photographic Representation of Street Lighting Installations," Mr. R. G. Hopkinson. 6.30 for 7 p.m.

INST. OF AUTOMOBILE ENGINEERS.—The Cavendish Café, Cornmarket, Derby. "The General Question of Supercharging," Mr. Oliver Thornycroft. 7.30 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Coventry Graduates' meeting, at Broadgate Café, Coventry. "Electrical Speed Indicating Equipment," Mr. G. A. Freeman. 7.15 p.m.

INST. OF AUTOMOBILE ENGINEERS.—The George Hotel, Luton. "Inspection and Quality Control," Mr. M. C. Park. 7.30 p.m.

INST. OF CIVIL ENGINEERS.—Great George-street, S.W.1. "Treatment of Mud Runs in Bolivia," Mr. S. W. F. Morum. 6 p.m.

INST. OF ELECTRICAL ENGINEERS: N. MIDLAND STUDENTS.—Hotel Metropole, Leeds. "Pollution of Suspension Type Insulators on Overhead Lines," Mr. K. C. Coop. 7.15 p.m.

INST. OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—39, Elmbank-crescent, Glasgow, C.2. "Diesel-electric Paddle Boat 'Talisman,'" Mr. G. A. Inglis. 7.30 p.m.

INST. OF METALS.—James Watt Memorial Inst., Birmingham. "Recent Developments in Refractories," Mr. C. E. Moore. 7 p.m.

INST. OF STRUCTURAL ENGINEERS: SCOTTISH BRANCH.—University Old College, Edinburgh. "Bridges," Mr. J. Shannon. 7.15 p.m.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. "Oxygen in Steel," Dr. L. Reeve. 7.30 p.m.

WEDNESDAY, DEC. 18TH.

CRYSTAL PALACE SCHOOL OF PRACTICAL ENGINEERING.—189th Award of Certificates by Mr. Cecil Molesworth Bunbury. 3 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Birmingham Graduates' visit to Colmore Repair Works, Cherrywood-road, Bordesley Green. 7.30 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Engineers' Club, Manchester. "Rotary Valves," Mr. R. C. Cross. 7 p.m.

INST. OF AUTOMOBILE ENGINEERS.—Hotel Metropole, Leeds. "Inspection and Quality Control," Mr. M. C. Park. 7.15 p.m.

INST. OF CIVIL ENGINEERS.—Students' meeting. Great George-street, S.W.1. Vernon Harcourt Lecture, "Tidal and River Models," Prof. A. H. Gibson. 6.30 p.m.

ROYAL METEOROLOGICAL SOC.—49, Cromwell-road, S. Kensington, S.W.7. Meeting. 4.30 for 5 p.m.

ROYAL MICROSCOPICAL SOC.—B.M.A. House, Tavistock-square, W.C.1. Meeting. 5 for 5.30 p.m.

SOC. OF CHEMICAL INDUSTRY: ROAD AND BUILDING MATERIALS GROUP.—At Rooms of Chemical Soc., Burlington House, Piccadilly, W.1. "Identification of Bitumens by Calorimetric Methods," Mr. D. C. Broome. 8 p.m.

THURSDAY, DEC. 19TH.

INST. OF AUTOMOBILE ENGINEERS.—Bristol Graduates' meeting at Merchant Venturers' Technical College, Bristol. Paper by Mr. C. E. Squire. 7.30 p.m.

INST. OF ELECTRICAL ENGINEERS.—At Savoy-place, W.C.2. "A Cathode Ray Oscillograph with High-speed Drum Camera Rotating in Vacuo," Mr. G. A. Whipple. 5.30 for 6 p.m.

INST. OF STRUCTURAL ENGINEERS.—10, Upper Belgrave-street, S.W.1. "Design and Construction of an All-welded Multiple-storey Steel Structure," Mr. R. W. MacBride. 6.30 p.m.

FRIDAY, DEC. 20TH.

JUNIOR INST. OF ENGINEERS.—39, Victoria-street, S.W.1. Informal meeting, "Film on Fabrication and Application of Hewittic Rectifiers." 7.30 p.m.

INST. OF STRUCTURAL ENGINEERS: MIDLAND COUNTIES BRANCH.—James Watt Memorial Inst., Birmingham. "Some Recent Experiences of Structural Engineering in the United States of America," Mr. H. C. Rowan. 6.30 p.m.

SATURDAY, DEC. 21ST.

SHEFFIELD METALLURGICAL ASSOC.—198, West-street, Sheffield, 1. Young People's Christmas Party. 3.30 p.m.

SATURDAY, DEC. 28TH.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1.—Christmas Lecture, "Photography: I, Beginning of Photography," Dr. C. E. K. Mees. 3 p.m.

TUESDAY, DEC. 31ST.

ROYAL INST. OF GREAT BRITAIN.—21, Albemarle-street, W.1.—Christmas Lecture, "Photography: II, Modern Photography," Dr. C. E. K. Mees. 3 p.m.

LAUNCHES AND TRIAL TRIPS.

SONAVATI, single-screw motor vessel; built by Harland and Wolff, Ltd., Govan Shipyard, to the order of Bombay Steam Navigation Company, Ltd., Bombay; dimensions, 249ft. by 42ft. by 24ft. 3in.; to carry cargo and passengers. Oil engines of Harland-B. and W. two-cycle, trunk system, poppet valve type; constructed by the builders; launch, November 26th.

ELONA, single-screw motor tanker; built by Swan, Hunter and Wigham Richardson, Ltd., to the order of Anglo-Saxon Petroleum Company, Ltd., London; dimensions, 425ft. by 54ft. 3in. by 31ft.; to carry oil in bulk. Oil engines, Werkspoor type (six-cylinder, four-cycle, solid injection, single-acting, supercharged); constructed by R. and W. Hawthorn, Leslie and Co., Ltd.; launch, November 27th.

ATHLONE CASTLE, Royal Mail motor ship; built by Harland and Wolff, Ltd., Belfast, to the order of the Union Castle Steamship Company, Ltd.; dimensions, 725ft. by 82ft., gross tonnage 25,000 (approximately); to carry mails, passengers and cargo. Oil engines, double-acting two-cycle Harland-B. and W. type, ten cylinders, diameter 660 mm., piston stroke 1500 mm.; constructed by the builders; launch, November 28th.

CLEARPOOL, steamer; built by William Gray and Co., Ltd., to the order of Pool Shipping Company, Ltd. (Sir R. Ropner and Co., Ltd., managers); dimensions, 440ft. 10in. by 55ft. 2½in. by 30ft. 2½in.; to carry cargo and a few passengers. Engines, geared turbine unit; constructed by Central Marine Engine Works of the builders; a speed of 12½ knots was attained on trial trip, November 28th.

CONTRACTS AND ORDERS.

The Editor is always happy to print short announcements of contracts and orders in this column provided they are sent to him in time to have news value and that they are likely to interest readers.

BABCOCK AND WILCOX, Ltd., have received an order from the South African Railways and Harbours Board for fourteen 4-ton electric portal luffing jib cranes for Port Elizabeth Harbour, and an order for twelve similar cranes for Table Bay Docks.

NEGRETTI AND ZAMBRA, 38, Holborn-viaduct, London, have received an order for the complete equipment of dial thermometers and pyrometers for the engine and boiler-rooms of the Q.S., T.S. "Queen Mary." The installation comprises 112 mercury-in-steel dial thermometers and 24 thermo-electric pyrometers.

RUSTON AND HORNSBY, Ltd., Lincoln, have received orders from film studios for oil engines totalling nearly 3000 b.h.p. These orders are as follows:—One 600 b.h.p. and one 450 b.h.p. engine for Warner Brothers First National Productions, Ltd., Teddington; repeat order for four 440 b.h.p. oil engines for a new film studio which is being built by Sound City, Ltd., Shepperton.

THE CAMBRIDGE INSTRUMENT COMPANY, Ltd., informs us that the new coke ovens erected in connection with the Orgreave by-product plant of the Rothervale Collieries, which are owned by the United Steel Companies, Ltd., of Sheffield, are being equipped with three Thomas gas meters constructed by the company. One meter for measuring the producer gas supplied for heating the coke ovens will have a maximum capacity of 800,000 cubic feet per hour. The second meter, for the coke gas delivered to the gasholder, will have a capacity of 500,000 cubic feet per hour, and the third meter, for surplus coke-oven gas used in the coke ovens, will have a capacity of 300,000 cubic feet.